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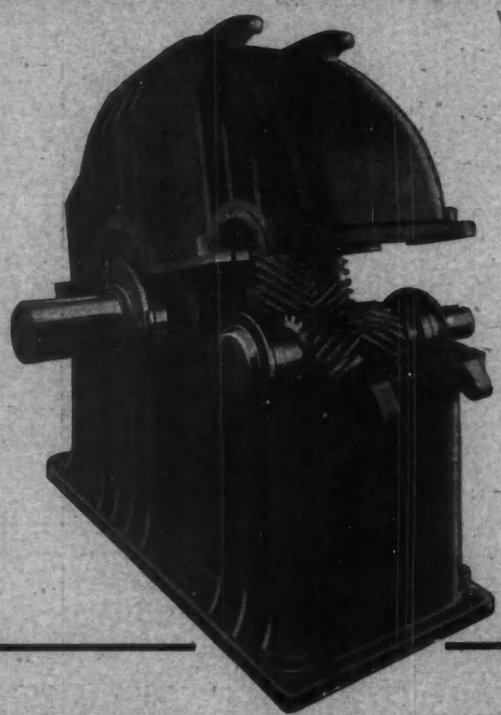

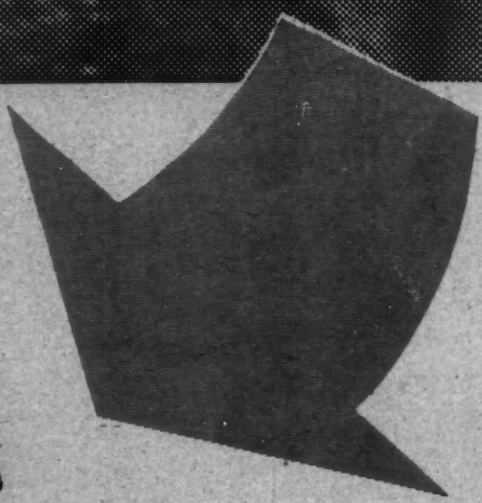

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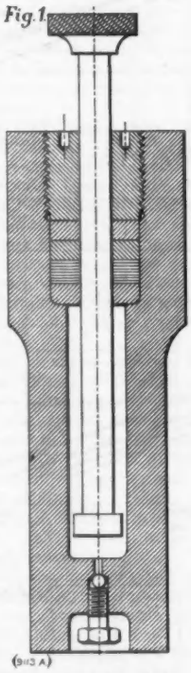
LIQUID SPRINGING.

By A. E. BINGHAM, M.I.Mech.E., F.R.Ae.S.

THE term "liquid springing" is now generally understood in the aircraft industry, but it is little known in the broader field of general engineering. Engineers know that nothing is incompressible, which is another way of saying that nothing is perfectly rigid; but the degree of rigidity or compressibility varies greatly in the wide range of materials now used. Compressibility must not be confused with deformability; it is easy, for example, to deform rubber and similar materials, but a high pressure is required to reduce their bulk to any considerable extent.

Fig. 1.



It is unfortunate that the phrase "liquids are incompressible" is commonly used, for the phrase is fallacious. The first attempt to compress water was made at the Florentine Academy, several centuries ago, by sealing water in a lead sphere and then trying to crush it. About the middle of the Eighteenth Century, Canton experimented with apparatus similar to a large bulb thermometer with a fine capillary, and applied pressure by an air pump. Although his work was published in the *Proceedings* of the Royal Society in 1762 and 1764, the poor materials and apparatus then available produced inconclusive results. In the first half of the Nineteenth Century, Perkins made progress on high-pressures. He realised the inadequacy of an open mercury column for measuring high pressures and introduced the "free piston gauge" which Amagat developed later. Amagat, in France, started research on the compressibility of fluids, culminating in his classic paper published in 1893. He used the Eiffel Tower to support a mercury column in his earlier experiments, and realised pressures of 45,000 lb. per square inch, a remarkable feat for that period.

Modern research on the subject started with the work of the Hon. C. A. Parsons and S. S. Cook,* whose apparatus consisted of a steel cylinder, 4 in. bore and 12 in. outside diameter. The ram was forced into the cylinder by means of a 2,000-ton hydraulic press. This experiment was considered so dangerous that the apparatus was housed in a strongly-built room and observations were made from outside. One important method was established: to eliminate the friction effect, hysteresis loops of the compression and expansion strokes were plotted and the mean curve was taken to give the internal pressure. This method has been used for the development of the liquid spring and found to be sufficiently accurate for all practical purposes.

At Harvard University, in 1906, P. W. Bridgman started 25 years' work, the results of which were published in his book *The Physics of High Pressure*; it covers a vast field, only part of which is applicable to "liquid springs." This work formed the foundation of the specialised research necessary for the development of liquid springs. Mr. Bridgman has continued his work up to the time of writing and has just been awarded the Nobel Prize for his high-pressure research. The aim of the physicist is to obtain the absolute compression of the fluid at increasing pressures and at various temperatures. Many methods are described in considerable detail in Bridgman's book, and still others are given in Professor D. M. Newitt's *High Pressure Plant and Fluids at High Pressure*.

In 1938, the compressive properties of a number of fluids being already known, Mr. George H. Dowty conceived the idea of using a liquid as a springing medium and, at the same time, using that same volume of liquid as a dash-pot medium. His first patent covering the system was taken out in 1939. From that date onward, intensive research was carried out by his firm, Messrs. Dowty Equipment, Limited, and the ways of the physicist and the engineer began to divide. In the physical laboratory, the life of the high-pressure gland is immaterial, but, in applying the physical phenomena to engineering practice, the life of the gland is all-important. Leakage must be reduced practically to zero and friction must be within reasonable limits. These two conditions are opposed.

The first experimental cylinder is shown in Fig. 1, herewith. Its main dimensions were: internal diameter, $\frac{3}{4}$ in.; external diameter, $1\frac{1}{4}$ in.; plunger diameter, $\frac{11}{16}$ in. The gland consisted of a simple disc of synthetic rubber with a substantial diametral interference in the housing and on the plunger. This sealed satisfactorily up to 20,000 lb. per square inch. Many types of glands were tested in a great variety of geometric forms and a wide range of materials. Hardened steel plungers were tried, but subsequently all plungers were made of ductile steel.

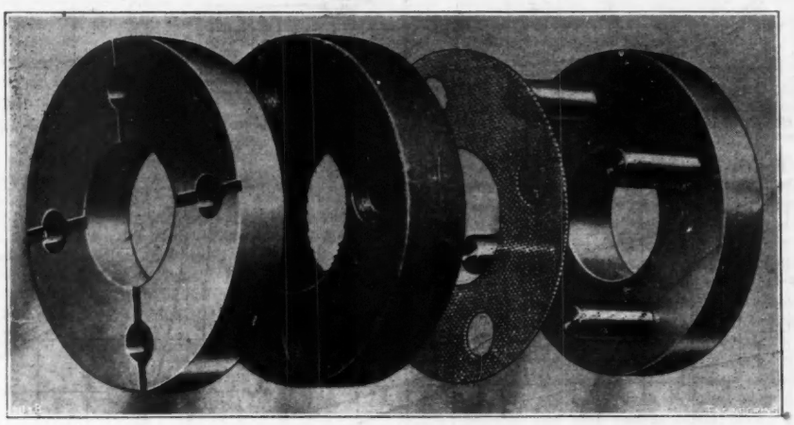
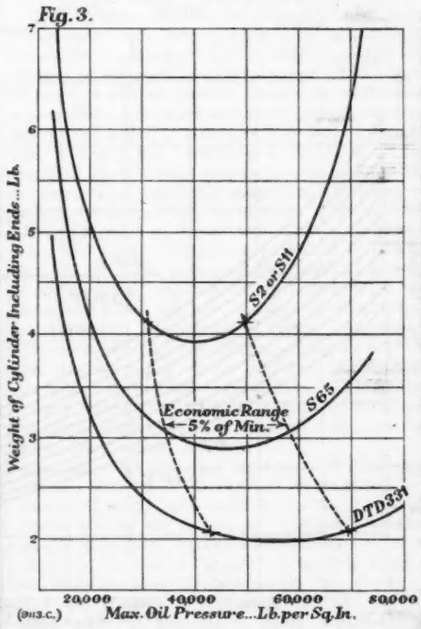


FIG. 2. COMPONENTS OF HIGH-PRESSURE GLAND.

Fig. 3.



Interest turned to synthetic glands with various types of reinforcement. Improved sealing resulted, but frequently it was difficult to dismantle the apparatus after attaining pressures of 30,000 lb. per square inch or more. The trouble was traced eventually to the trapping of pressures in the gland assembly, and a solution was found by introducing a foraminated layer between the gland and the washer. This consists of two layers of fine-mesh wire gauze, set so that the respective meshes are at 45 deg. to each other.

To design a gland which will not leak at high pressure is simple, provided that friction and wear can be ignored. Alternatively, if a small amount of leakage can be tolerated, friction can be reduced to a low figure. For a liquid spring, a compromise is required. The solution was found in the "unsupported area" type of gland (British Patent No. 539,966). An exploded view of the gland is shown in Fig. 2, herewith.

The pressure acts over the full annular area of the gland assembly (the pegs being rigidly attached to the inner washer); and the gland-ring area is the full annular area less the area of the pegs. As the total force in each direction must be balanced, the pressure in the gland ring must be higher than the oil pressure; therefore, leakage is eliminated. To prevent extrusion of the gland through the working clearances round the piston rod and pegs, chamfer rings are provided, made of a tough bearing material. The amount of out-of-balance area has been determined by experiment. The gland is on a synthetic base reinforced with fabric. The backing washer has relief grooves communicating with the peg holes to prevent an accumulation of pressure, which would destroy the out-of-balance condition.

For calculating the strength of thick cylinders, Lamé's formula, which has been verified for this class of work by photo-elastic methods, is used. In 1939 and 1940, a number of bursting tests were carried out on cylinders and, in every case, the bursting pressure was considerably higher than that calculated by this formula. The reason for this is that, when the plastic range is reached, there is a redistribution of stress and the difference between the stress at the inside diameter and that at the outside diameter is reduced. This provides an added factor of safety. In all these tests, failure

* *Proc. Royal Soc.*, Series A, vol. 85, No. A 579, pages 332-345 (1911).

LIQUID SPRINGING.

Fig. 4.

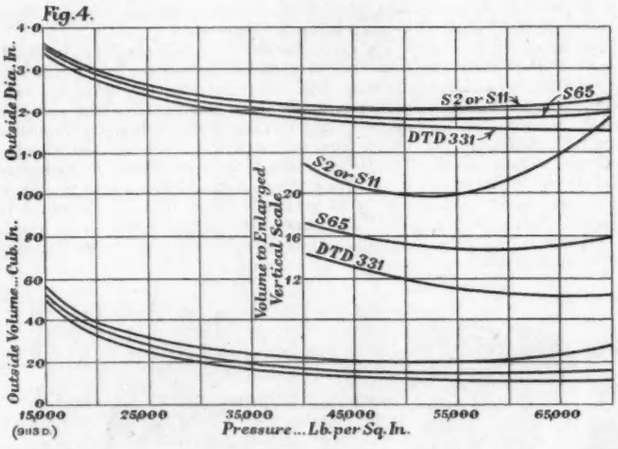


Fig. 5.

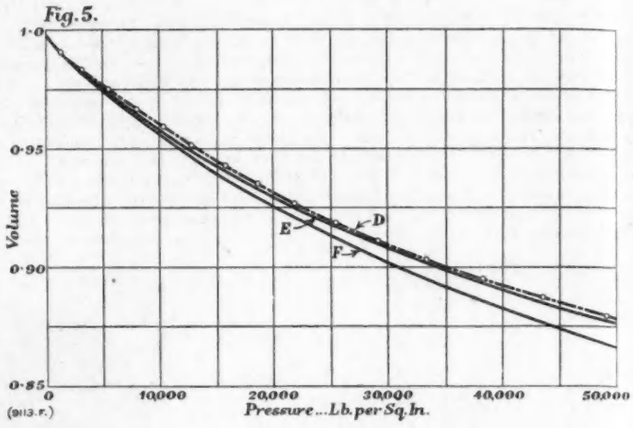


Fig. 6.

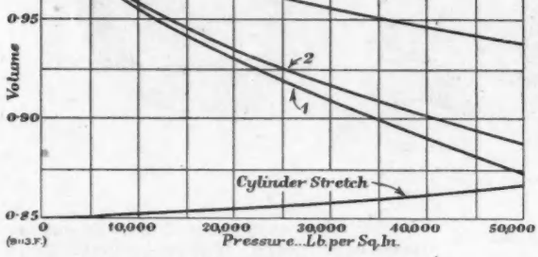
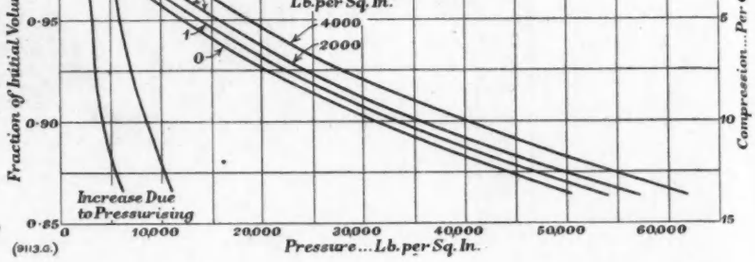


Fig. 7.



occurred as a simple split, parallel to the cylinder axis. Long-term fatigue tests indicated the importance of good surface finish, and of the elimination of sharp corners. When a cylinder fails, there is no danger to personnel, because no metal is projected; with liquid as the pressure medium, the stored energy is comparatively small.

In the design of cylinders, pre-stressing, multiple sleeving, and wire winding have all been considered and abandoned as uneconomic. For the same volume of liquid, the weight of the barrel portion is unaffected by the length/diameter ratio, but for short cylinders the ends are heavier, so it is an advantage to make the cylinder as long as possible.

The compressibility of all fluids decreases with increasing pressure and the strength efficiency of a plain cylinder decreases with increasing pressure. Fig. 3, on page 289, has been plotted to determine the optimum pressures for various steels, in the case of a cylinder with a 5-in. barrel and 3-in. stroke, to support a load of 10,000 lb. The design is based on the thick-cylinder theory, the stressing pressure being 4/3 of the realised pressure. The three curves shown all drop to a minimum and then rise again steeply. The economic range has been chosen, arbitrarily, as being within 5 per cent. of the calculated minimum, and, for the steels quoted, the critical range lies between 45,000 and 50,000 lb. per square inch. Fig. 4, on this page, gives a similar series of curves, relating to external volumes, for the same cylinder as in Fig. 3. These do not rise so quickly after the minimum is reached.

The direct stress in the plunger is the same as the fluid pressure and, as there are also bending and strut effects, stressing problems are difficult with pressures above 50,000 lb. per square inch. Taking these points into consideration, together with the fact that gland wear increases as the pressure rises, there is little to be gained by using pressures above 50,000 lb. per square inch.

Throughout this article, the compressibility is expressed as the reduction in volume due to pressure divided by the volume at atmospheric pressure (temperature remaining constant). For design purposes, it is necessary to know the absolute compressibility of the fluid, the compressibility of the gland material, and the elastic stretch of the cylinder. The sum of these quantities gives the apparent compressibility. As E (Young's modulus) for steel is almost constant, the apparent compressibility will increase with higher-tensile steels, as the elastic (cylinder) stretch is proportional to the ultimate strength of the steel.

Fig. 8.

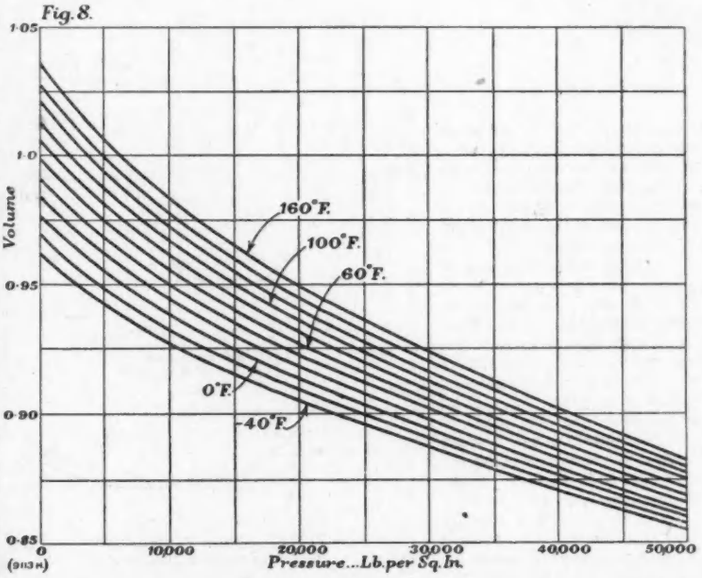
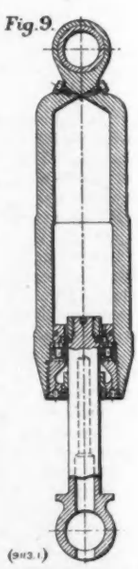


Fig. 9.



The absolute quantities can be determined experimentally by using first the plain cylinder and then inserting a known quantity of the synthetic gland material and, alternatively, a known volume of steel. By making three tests in a cylinder with a plunger only, three equations are obtained. At any pressure (p) where s = volumetric stretch of cylinder, g = volumetric compression of gland, V_1 = initial volume of liquid, V_2 = volume of synthetic material inserted, V_3 = volume of steel sleeve inserted, C = unit absolute compressibility of liquid, C_1 = unit absolute compressibility of synthetic material, D_1 = plunger displacement with full liquid volume, D_2 = plunger displacement with synthetic material inserted, D_3 = plunger displacement with steel sleeve inserted, and K = bulk modulus of steel (23×10^6 lb. per square inch),

$$D_1 = \overline{s + g} + C V_1 \quad . \quad . \quad . \quad . \quad (I)$$

$$D_2 = \overline{s + g} + C(V_1 - V_2) + C_1 V_2 \quad . \quad (II)$$

$$D_2 = \overline{s+g} + C(V_1 - V_2) + \frac{p}{K V_2} \quad . \quad \text{(iii)}$$

Subtracting eq. (iii) from eq. (i),

$$D_1 - D_2 = C V_2 - \frac{(p)}{K V_2};$$

from which C can be calculated, and $\overline{s+g}$ determined from eq. (i) and C_1 from eq. (ii). The volume of the gland is known, therefore s can be determined. It should be noted that equations (i) and (ii) are not soluble independently, because they are not really dissimilar. It is necessary, therefore, to introduce the value V_2 (volume of steel sleeve) independently to obtain eq. (iii).

Although the volume of a liquid continues to decrease with increasing pressure, the rate of decrease in volume gradually lessens; in other words, the instantaneous compressibility decreases with increasing pressure. The strength efficiency of the cylinder also decreases with increasing pressure, and these two functions account for the variations in the weight and overall volume, to which reference was made above.

The compressibilities of a large number of fluids have been determined. Identical cylinders were used for these tests and their stretch was known, so that the absolute figures could be calculated. Fluids for liquid springs must have properties other than good compressibility. The fluid must be a lubricant, have a low pour point and a reasonably high flash point, and should not be toxic or have properties which would make it unpleasant or dangerous to handle. Ether, for example, is highly compressible, but all its other properties are undesirable.

Fig. 5, opposite, shows apparent compressibility curves, from a cylinder of S.11 steel, with the origin at unit volume and atmospheric pressure. The gland is of the special unsupported-area type, previously mentioned. Curve D relates to Intava oil (D.T.D. 44c) with 5 per cent. of colloidal graphite, at a temperature of 66 deg. F.; and curve E to the same oil, pure, at 69 deg. F. Curve F relates to the same oil as curve E, but used in a cylinder of nickel-chrome steel (D.T.D. 331) with the thickness correspondingly reduced.

Fig. 6 shows the apparent and absolute curves (1 and 2, respectively) for the same light graphited mineral oil, the absolute curve (3) for synthetic rubber (85-95 Shore), and the cylinder stretch, including gland compression, as a percentage of the initial oil volume. The latter is only a small proportion of the apparent figure, and it should be noted that the actual volume of synthetic rubber is a small percentage of the oil volume. Fig. 7 shows the effect of providing an initial pressure before the plunger is deflected. This is known as "pressurising." The oil is AN-VV-O-366B (D.T.D. 585) at 69 deg. F., in a cylinder of D.T.D. 331 steel. The curve O is the ordinary compressibility curve, starting at atmospheric pressure; curves 1, 2, and 4 start at 1,000, 2,000 and 4,000 lb. per square inch, respectively. On the left are two curves which show the increase in pressure, at various deflections, due to initial pressurising at 2,000 and 4,000 lb. per square inch. These curves are of unexpected shape, the pressure increase rising rapidly with plunger deflection.

The effect of temperature on viscosity is well known and, in choosing a liquid, it is important to know the lowest operating temperature. For aircraft, the figure can be quite low, even when operating in tropical countries, as the aircraft may fly at a considerable altitude for many hours and descend so rapidly that most parts are still cold at the moment of touch-down. In arctic regions, it is necessary to have a liquid which will not freeze at −40 deg. F. or lower. Fig. 8, opposite, shows the effect of temperature on a light mineral oil (Intava, Specification D.T.D. 44C) such as is used in aircraft circuits, in a cylinder of S.82 steel. Unit volume at atmospheric pressure has been taken at 60 deg. F.

At any pressure, the coefficient of expansion remains constant, but, as the pressure increases, the coefficient of expansion decreases. The influence of temperature becomes less as pressure increases; but, as compressibility increases with increasing temperature, the latter effect tends to compensate the temperature influence. No mathematical relationship between viscosity, coefficient of expansion and compressibility has been found. In general, the more compressible fluids in the same group have a lower viscosity and a higher coefficient of expansion. Between different groups of liquids, such as petroleum-base, vegetable-base and synthetic base, there appears to be no relation, and glycerine is in a class by itself.

In a liquid spring which also acts as a shock absorber, a dash-pot function must be incorporated. In shock absorbers for aircraft and similar applications, the dash-pot orifice is controlled so that the recoil velocity is less than the compression velocity. Fig. 9, opposite, shows a section through a liquid spring used on a Handley-Page Halifax bomber. The piston carries a ring valve which lifts on the compression stroke, opening all the orifices. On the recoil stroke, the valve closes all but one of the orifices, so that the recoil stroke is much slower than the compression stroke. The shape of the stroke/reaction curve is important, especially if comfort is involved; a too-efficient shock absorber on an aircraft or road vehicle can give too great a change in acceleration, leading to unpleasant sensations. It may be mentioned that the piston has no influence on the compression of the liquid beyond the comparatively small effect due to differential pressure.

The filling of liquid springs is a simple operation. Two filler plugs are provided; oil is poured into one, and the air flows out of the other. Pressure filling can be effected where necessary by a filler valve of the non-return type. A pressure of 1,500 to 2,000 lb. per square inch can be built up by means of an ordinary grease gun.

LITERATURE.

Structural Engineering. By PROFESSOR JOSEPH HUSBAND and WILLIAM HARBY. Fifth edition. Longmans Green and Company, Limited, 43, Albert-drive, London, S.W.19. [Price 21*s.* net.]

THIS book is a revised and enlarged edition of a well-known work first published in 1911, when structural engineering was a subject mainly of interest to designers of structural steelwork. Even in the first edition, however, masonry construction was carefully considered, and, in subsequent editions, matter was added on influence lines and on cement and concrete, and references in the text to the standard specifications and code were brought up to date. It is somewhat surprising, therefore, to find in the new edition no reference to the findings of the Committees, which were already in session when the fourth edition was published, on Bridge Stresses and Steel Structures Research. The book is not intended, however, for research workers and others skilled in the use of higher mathematics; for extensive treatment of highly specialised structures, and of design methods of limited application, the advanced student will look elsewhere as his needs may dictate. The authors' aim is limited to the provision in a single volume of the basic theory in structural design, illustrated by examples drawn from current practice.

In earlier editions, the treatment of reinforced-concrete structures was omitted as constituting a branch of study more appropriate to specialised works, but its use is now so widespread that no structural engineer, whatever his ultimate speciality, can avoid the need to acquire, at an early stage in his training, some competence in the design of structural elements in reinforced concrete. Accordingly, and "in response to many requests," the authors have added five new chapters dealing, respectively, with the general principles of reinforced concrete, its application to the design of beams and slabs, of columns, of retaining walls, and of tanks and reservoirs, followed by an appendix on the strength of concrete of various grades, and on appropriate methods of testing. The index to the new chapters has been kept separate from the general index, which may or may not be an advantage. The treatment follows in the main the recommendations of the *Code of Practice for Reinforced Concrete* drawn up by a committee appointed by the Department of Scientific and Industrial Research and published in 1934, and still, in this country, the recognised guide to good practice. The new chapters are written in the same clear style and with the same practical approach as the older part of the book.

There must be a limit to the expansion of a book contained within a single cover, and it would be hard to indicate any existing part of this well-arranged work which could be discarded, but it may be suggested, nevertheless, that when (as is probable) a sixth edition becomes necessary, consideration might be given to the inclusion of brief sections on welded steel structures and on the design of modern structures in timber. By that time, also, the Codes of Practice being compiled under the ægis of the Ministry of Works will require consideration by the authors of text-books. Meanwhile, the present edition will prove to students and designers of the present day as useful as previous editions were to their colleagues of the recent past, since no other British text-book covers, within equal compass, quite the same range of practical instruction.

Fundamentals of Shopwork. By D. J. SWARTZ, M. J. GUNERMAN, and A. LAPON. E. and F. N. Spon, Limited, 57, Haymarket, London, S.W.1. [Price 15*s.* net.]

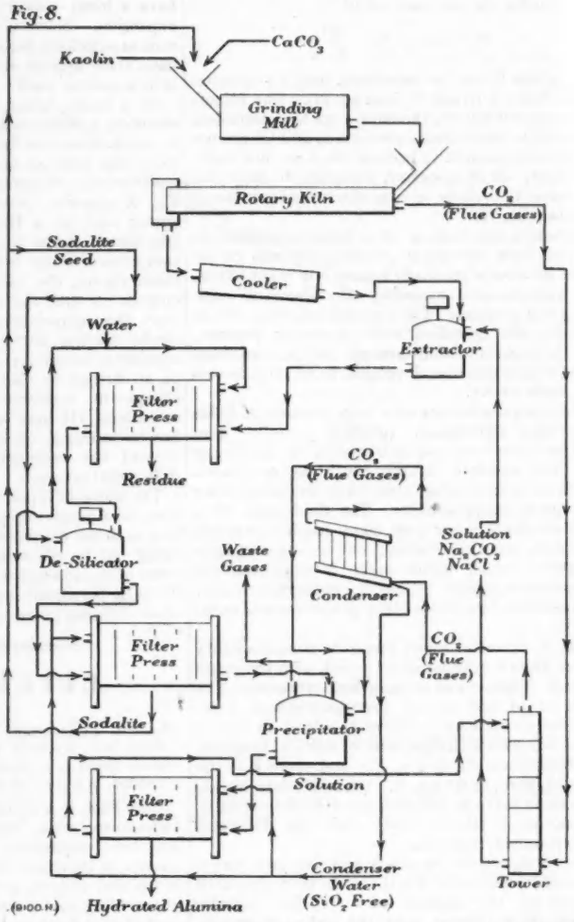
ALTHOUGH attractively produced and well illustrated, this book is curiously uneven in the text, a fact possibly explained by its earlier history, for it was originally devised as an instructional guide for United States Army "inductees" at the request of the (American) War Department and the United States Office of Education. It appears that the text dates from 1943, although this is a matter of relatively small moment. In any future edition, however, certain obvious omissions ought to be made good. Welding is dismissed with a mere definition; and brazing (after definitions) with the comment, "To do good work in hard soldering, much practice and skill are required. Soft steel [*sic*] is easier to use. We shall therefore devote the rest of this section to soft soldering." Chapter VI, "Wiring and Wire Splicing" is extremely restricted in its scope; if reinforced by more information on the electrical aspects, it could be much improved. The introductions to some of the chapters savour of the preamble a teacher may use to win the interest of a not very intelligent class and might well be omitted. The practical examples of different rope knots, lashings, and splices are excellent; but the authors fail to explain the fundamental principle of the mechanical advantage obtained with blocks and pulleys, though they devote much space to examples of various arrangements and the results given by them. This is a common failing in American books of this kind; and the present work is very American in character. British readers must beware, too, of certain essential differences in phraseology between the two countries; thus "even" numbers are called "equal" numbers; "bus bars" are simply heavy-gauge copper wire for electrical connections; and so on. The American system of projection is used, of course, in the line illustrations where projection is necessary, but it is now fairly familiar; and the section on screw threads stands as a reminder of a fundamental difference which constituted one of the seemingly small but actually far-reaching difficulties encountered in the production of war stores for the Allied armies. On the whole, the woodworking section (chapter IV) is the most satisfying in a book which, despite the shortcomings mentioned, has much good practical advice to offer, and should be of interest to workshop instruction classes in technical schools, where the excellent illustrations and descriptive sections of the text are likely to be most appreciated.

"THE ALUMINIUM COURIER."—A copy of a new publication bearing the title, *The Aluminium Courier*, has been sent to us. It is published by the Aluminium Development Association, 33, Grosvenor-street, London, W.1, and is intended to promote one of the main objects of the Association, namely, encouraging and increasing the correct use of aluminium and its alloys. It will appear at approximately quarterly intervals and is addressed to users and prospective users of the metal. Each issue will deal mainly with a specific application of aluminium, and this, the first issue, is devoted to structural engineering and building. The next issue to appear will deal with road transport.

THE EXTRACTION OF ALUMINIUM FROM CLAY.

FIG. 7.

Fig. 8.



THE EXTRACTION OF ALUMINIUM FROM CLAY.

(*Concluded from page 266.*)

THE final stage in the process is the conversion of the hydrated aluminium chloride to alumina by calcination. This is carried out in a muffle furnace, the material being constantly agitated by rabble arms as it passes downward over the heated hearths. The agitation makes the conversion from chloride to oxide a continuous process and effects conversion at a lower temperature than would otherwise be necessary. The chloride crystals obtained from the centrifuge are fed by hand into a hopper at the top of the furnace, and the alumina emerging at the bottom is removed by a vibrating conveyor so arranged that the 6 in. glass outlet pipe by which the conveyor is fed is always filled with the oxide. This prevents air from entering the furnace and diluting the hydrochloric-acid gas issuing from the top. The lower part of the furnace and the conveyor are illustrated in Fig. 7, on this page. The hydrochloric-acid gas and water vapour are drawn from the top of the furnace by a rubber-coated exhaust fan. The acid gas is drawn through a cooler, where a certain amount of the aqueous acid condenses and is drained into a still for later generation of hydrochloric-acid gas used in the process. The major part of the acid gas, after passing through the cooler, is absorbed in cool hydrochloric acid of constant boiling strength in an absorption tower, by the same technique as that used in the precipitation of aluminium chloride. In this way, the constant-boiling acid is built up to acid of specific gravity 1·18 to 1·20 and is then pumped into a still and heated to produce hydrochloric-acid gas for precipitation of aluminium chloride.

The alumina produced by this method has an average purity of about 99·8 per cent. The only significant impurities are 0·1 per cent. chlorine, 0·04 per cent. iron oxide, and 0·06 per cent. silica. If a purer product is desired, the chlorine content can be further reduced by longer heating at higher temperatures, and the content of iron oxide may readily be lowered by additional washing of the chloride in the centrifuge basket. It is stated that, in addition to its use in the production of aluminium, the alumina is superior to any on the market for polishing metallographic specimens. Exceptionally good results have also been obtained with this alumina in the preparation of enamels for use at high temperatures, probably due to the extreme fineness of the product. As already mentioned, the cost of producing aluminium by the hydrochloric-acid process is about twice that of metal produced from imported bauxite. The two major items in the cost are fuel for heating and replacement of hydrochloric acid. Greater efficiency in the re-use of hydrochloric acid offers possibilities of economy, as does the better use of power through more efficient heat exchangers and the utilisation of waste heat from furnace gases. There are also possibilities of the recovery of usable by-products, such as iron.

The alkaline method of extracting aluminium from kaolin, which has been worked out by the Bureau of Standards, has not been carried to such an advanced stage as the acid process and no semi-commercial pilot plant has been built. The results obtained represent only those furnished by the laboratory stage. The basic methods of the alkaline process had been established by October, 1943, but as, by that time, satisfactory supplies of bauxite were being safely conveyed from South America, it was not considered necessary to spend further time and money on this alternative to the acid method, which was giving promising results. One of the fundamental principles of the alkaline process is the conversion of the alumina in the ore to sodium aluminate, which is readily soluble in water. Any iron present is easily removed, as it is insoluble in alkali; but with an alkaline treatment of the ore, considerable silica remains in solution. The main problem is to get rid of this silica content.

There are three principal methods of extracting alumina from the ore in the form of sodium aluminate. These are: direct extraction by treating the ore with sodium-hydroxide solution; treatment of the ore to give a product containing solid sodium aluminate; and treatment of the ore to give a product containing calcium aluminate, which can be decomposed with sodium-carbonate solution. Each of these methods results in a sodium-aluminate solution containing soluble silica to the extent of 1 or 2 per cent. of the alumina present. This figure is too high to be acceptable and the problem presented is to reduce the silica to a much lower figure.

As a point of departure in the investigation of the alkaline process, the National Bureau of Standards made numerous extractions from samples of a high-silica bauxite which were treated with sodium-hydroxide solution at boiling temperature. Solutions of sodium aluminate, containing moderate amounts of silica, were obtained. Analyses of the insoluble extraction residues showed that soda, alumina and silica were present in constant molecular proportions, indicating that the residues might consist mainly of a single compound. Attempts were accordingly made to synthesise, from pure starting materials, a sodium-aluminium silicate compound similar in composition to the extraction residues. X-ray diffraction patterns of the resulting products strongly resembled those of the naturally-occurring mineral sodalite ($3Na_2O.3Al_2O_3.6SiO_2.2NaCl$). As a result of these observations, further extractions of the bauxites were made, using sodium chloride in addition to the sodium hydroxide, the result being that the silica content of the extracted solutions was immediately reduced to one-tenth, or

less, of the former value. The reduction in residual silica was caused by the formation during the extraction, of a compound of the sodalite type, having a significantly lower solubility than the sodium aluminium silicate which was formed when sodium chloride was not present. This was an important discovery, as it presented a method of reducing the silica in alkaline extraction solutions to a point at which alumina suitable for electrolytic reduction could be precipitated with carbon dioxide.

Numerous extractions were performed to determine optimum conditions and it was found that only about 75 per cent. of the alumina in the impure bauxite could be dissolved out with sodium hydroxide-sodium chloride solutions, the remainder forming an insoluble hydrated sodium-aluminium silicate. At the same time, soda was lost in the formation of this complex compound. Attention was accordingly directed to the recovery of the precipitated alumina and soda. The extraction residues were sintered with lime and the resulting solid sodium aluminate was extracted with water. The sodium-aluminate solutions thus obtained contained most of the soda lost in the first extraction and sufficient alumina to make the overall extraction of this material 90 per cent., or better. Silica was present only to the extent of 1 or 2 per cent. of the alumina and could be further reduced to a very low value by boiling in contact with a seed charge of sodalite in the presence of sodium chloride. It was important that it was discovered that the presence of sodium chloride had no adverse effect on the extraction of the alumina and soda from the residues. This meant that the spent solution from the precipitation of alumina with carbon dioxide could be re-circulated and used for extracting the sintered residue.

The results of these investigations, which showed that the proportion of silica could be reduced to a low value by the application of sodalite, led to experiments aiming at the more complete separation of silica from alumina in solutions obtained in the lime-sinter process. Ground silicious aluminium ore was mixed with finely-divided calcium carbonate in such proportions as to give a material equivalent to a mixture of dicalcium silicate with pentacalcium trialuminate and mono or tri-calcium aluminate. This mixture was heated at temperatures approaching 1,400 deg. C. for the time necessary for the formation of these compounds. The sinter was then slowly cooled to about 1,200 deg. C. to permit crystallisation of any liquid present to the higher temperature; it was then allowed to cool to room temperature without control of rate of cooling. The dicalcium silicate which was formed performed two important services: it held the silica in an unreactive form, insoluble in the alkaline extracting solution; and expanded on cooling so that the sintered mass was reduced to a powder, rendering the aluminous materials accessible to the action of an alkaline solution without grinding. It was found that the presence of sodium chloride in the extraction solution did not seriously interfere with the extraction of the alumina with sodium carbonate. This fact permitted further use of the spent solutions from which silica and alumina had been removed by precipitation, respectively, with sodalite and carbon dioxide.

These various experiments formed the basis for the establishment of a method of recovering alumina from clay by a lime-sinter process involving extraction with a sodium carbonate-sodium chloride solution. Although the lime-sinter process is not new in general outline, it was improved by utilisation of the sodalite method of de-silicating alumina solutions containing silica. A flow sheet of the suggested process is reproduced in Fig. 8, on page 292. A mixture of clay and limestone is prepared by either a wet or dry process of grinding and mixing. The raw mix is then burned and the resulting clinker annealed. Commercial equipment is available for this work, the plant consisting of an ordinary rotary kiln in series with a rotary cooler fitted with a burner at its feed end, the arrangement permitting the rate of annealing of the clinker to be adjusted. The product, which does not require grinding, is passed to an extractor in which it is subjected to the action of a solution of sodium carbonate and sodium chloride. The resulting slurry is stirred at high speed for about half an hour at a temperature of 60 deg. to 80 deg. C. On completion of the extraction period, the mixture is filtered and an extract containing 70 to 80 grammes of alumina and 1 to 2 grammes of silica per litre is obtained. By subjecting the residue to counter-current washing with salt solution, it is expected that the concentration of alumina in the wash water can be built up to approach that in the extract. The residue, consisting principally of lime and silica, may be washed with water and used as a raw material for the production of Portland cement.

The filtered alumina solution, plus the concentrated washings, pass to a de-silicator in which they are boiled for one hour with a seed charge of synthetic sodalite; this results in the precipitation of crystalline sodalite. After filtration, the sodalite in excess of that required for seed for the next batch is returned to the first stage of the process, as indicated in Fig. 8. In this way, the alumina and soda in excess sodalite are recovered. The de-silicated solution passes to a precipitator in which it is subjected to the action of carbon dioxide obtained from scrubbed kiln gases, hydrated alumina being precipitated. In order to avoid contamination by silica, the precipitation of alumina is not carried to completion. In the cyclical operation of the process, however, complete recovery of the alumina from solution would be obtained. The alumina is filtered and washed with water, low in silica to avoid contamination, the residual solution and washings being used to scrub the kiln-flue gases. This procedure not only removes dust from the gases but also evaporates water from the combined solution and washings. Sufficient make-up quantities of sodium carbonate and sodium chloride are added to the evaporated and carbonated solution, so that it may be used for the extraction of a fresh batch of sinter. The hydrated alumina is dried and calcined for electrolytic reduction to aluminium. About 95 per cent. of the alumina in the clay is recovered by this method and soda losses are small. An advantage of the process is that all steps can be conducted at atmospheric pressure; many alkaline methods for the extraction of alumina require autoclave de-silication.

NOTES FROM SOUTH AMERICA.

THE rapid depletion of the gold and foreign-currency assets of Latin America had already resulted in restrictions upon imports of non-essential goods (excluding machinery, etc.), while, in the River Plate countries and Brazil, the position has been further complicated by H.M. Treasury's announcement of the inconvertibility of sterling into dollars as from August 20. Britain's decision, however, mainly affects Argentina, and does not relate to "American account" countries, including Bolivia, Chile, Peru, Mexico and the Central American countries. The Treasury's announcement had immediate effects in Argentina, where the Central Bank temporarily suspended the issue of prior exchange permits for imports of all goods, irrespective of currency or country of origin. These steps naturally has a most confusing effect upon British export trade to Argentina, particularly in regard to current shipments. The position, however, was clarified as speedily as September 3, when the Central Bank of Argentina permitted the resumption of sterling dealings so as to provide exchange for imports from the United Kingdom covered by existing permits, while new permits are to be granted for certain imports, including chemicals, metals, coal and petroleum.

Even before Britain's change of policy on August 20, the rapid dwindling of Argentina's foreign currency assets had given rise to concern in local business circles. It was pointed out, for instance, that, instead of replacing worn-out agricultural and industrial machinery, automobiles, etc., by new models, money had been spent in acquiring old equipment, such as United States war materials (jeeps, etc.), while the view was advanced that it would have been better to spend money on improving the railways with new equipment rather than buying them outright. President Perón has indicated, however, that the inconvertibility of sterling will not interfere with the ratification of the purchase of British-owned railways in Argentina.

The Argentine Government explained that the August interruption of imports was only temporary, pending examination into the repercussions of the inconvertibility of sterling. It still remains a fact that Argentina's major object is to secure supplies of urgently-needed industrial, engineering and transport equipment (upon which the Five-Year Industrial Plan is dependent) in exchange for meat, grain, etc. Therefore, as money earned in the sterling area must now be spent there, it is quite possible that recent events may tend to result in a return of the close trading interdependence between Argentina and the United Kingdom which was so marked in pre-war years. Restoration of Anglo-Argentina trade must depend, however, upon mutual ability and willingness to take each other's products. Present circumstances form the real test for the Péron Government, who cannot afford to face the politico-economic consequences of any failure to continue to push ahead with the Five-Year Plan, capital supplies for which have come hitherto from the United States. In view of the lack of coal in Argentina, the avowed aim of large-scale industrialisation is dependent mainly upon the successful outcome of the electrification scheme in the North, called "Centrales Electricas del Estado," apart from a vast network of military and civil airfields. Argentina's large potential demand for transport items is shown by the fact that the State Merchant Fleet has placed contracts with Messrs. Cammell Laird and Company, Limited, of Birkenhead, for four refrigerated-cargo motor-vessels, each 8,400 tons gross, while two additional ships, each 7,500 tons, have been ordered from the Italian shipbuilding concern of Cantieri Riuniti dell' Adriatico; the total value of these orders is approximately 5,000,000*l.*, and the ships are expected to be in service by the end of 1949. The Empire Tractor Corporation, of Philadelphia and New York, have shipped 1,000 tractors, which have been purchased directly by the Government of Argentina at a cost of over 1,500,000 U.S. dols. Under a recent agreement, Argentina will supply France, over five years, with farming products in exchange for a wide range of manufactured articles, including iron and steel, transport materials, machinery, electrical appliances, agricultural implements and scientific instruments.

A provisional list of Argentina's requirements for electrical equipment for the next year, drawn up by the Department of Water and Electricity, includes 33 turbines, of which 16 are for heads of 100 metres or less; the highest head for the remainder is 435 metres for three of the turbines. The volume of water available varies from one cubic metre a second for the highest head to 126 cubic metres for a 23-metre head. A Bill now under consideration proposes to spend 30,000,000 pesos (say, 2,000,000*l.* sterling) on building a meat-packing plant at Rio Cuarto in the province of Córdoba.

In future, the proceeds of Brazil's exports to the sterling area must be used to buy goods from that area; but Brazil is not affected thereby to the same extent as Argentina, because Brazilian exports are mainly to the United States, so that dollars are normally in good supply. So far, therefore, there has been no further change in Brazil's import regime, which does not ban any imports, but merely gives priority to essential goods, particularly machinery and equipment and practically all transport items. An International Exhibition of Industry and Commerce, sponsored by the Federação Nacional do Comercio, will be held at Petropolis, Brazil, towards the end of this year. A Council has been set up by the Government of the State of São Paulo to advise on the development and increased use of electric power in that State. When inaugurating the first session of this new Council, the Secretary of Transport stated that the total electric power capacity in the State was divided mainly between the São Paulo Tramway, Light and Power Company—in the city of São Paulo district—and the Empresas Electricas Brasileiras, operating over an area representing some 40 per cent. of the State. A 92,000-h.p. generator is now ready for operation in the hydro-electric plant of the Usines do Cubatão, near Santos, Brazil. The installation will increase São Paulo's electric supply by one-fifth. Three additional generating units, each of 92,000 h.p., are now on order with a United States company; it is intended to install one in 1948, another in 1949, and the third in 1950. These generators will increase the capacity of the Cubatão plant to 762,000 h.p. The potential capacity of this power plant exceeds 1,500,000 h.p., which will make it one of the six largest hydro-electric systems in the world. The Santos Docks Company have placed an order in Scotland, for twelve non-propelling steel barges with a cargo capacity of 250 tons, for delivery within 18 months. The same company recently published their programme of improvements, but the Government of the State of São Paulo estimate that essential improvements at the port would cost the equivalent of about 13,000,000*l.* sterling. As it is considered that such a sum could be raised only with Government assistance, it is recommended that the administration of the docks be taken over by the State Government. Santos handles 40 per cent. of all Brazilian imports, and 45 per cent. of total exports. The State of São Paulo is endeavouring to obtain credits from the United States for public works.

There is likely to be an increasing demand for oil-drilling and refining equipment in Brazil, now that that country is considering the relaxation of the

mining code so as to admit foreigners. Already, North American concerns have made tenders to the appropriate Brazilian Government department (Consejo Nacional de Petroleo) for the erection of a refinery in the State of Bahia. Petroleum development is also bringing remarkable prosperity to Venezuela. A Government plan of public works includes improvements at the port of La Guaira as well as a large dry dock at Puerto Cabello. The Government of Colombia have presented to Congress a project for extending a railway down the Magdalena River valley from La Dorada to a point where the river is at all times navigable.

Following the example of other Latin-American countries which suffer from foreign-exchange shortage, Chile has just issued a decree which prohibits imports of goods regarded either as luxury articles or not indispensable. This list does not include any engineering items, factory equipment or other capital goods, which are in particularly urgent demand in Chile in view of the country's widespread industrialisation plans. The President of Chile has presented to the new Ministry a comprehensive plan of national action, which proposes, *inter alia*, to finance the State Railways at 330 million pesos per annum, and the Empresa Nacional de Transportes Colectivos (omnibus and tramway system) for 200 million pesos, to co-ordinate transport and various public works, especially roads, irrigation, railways, ports, etc. Fares on tramcars and omnibuses were raised steeply on August 10 in an effort to solve the long-standing financial problems of the national transport undertaking. Plans for the irrigation of the Azapa Valley, in the Northern part of Chile, drawn up by the Chilean Irrigation Department, have been approved. The estimated cost of the project is 938,000 U.S. dols.

Chile is negotiating with the Skoda works at Pilsen for the delivery of the complete equipment for a sugar-mill, which will cost some 3¼ million dols. This mill will be the first of its kind in Chile, with a yearly capacity of 100,000 tons of sugar, and should begin production in about 18 months. Chile will pay for the whole plant with copper, nitrate and other raw materials. The project for an underground railway in Santiago has been raised again, and it has been stated that the Minister of Public Works intends to invite tenders from contractors in the United States, the United Kingdom, France, Sweden and Italy. According to latest reports on the construction of the Antofagasta-Salta Railway, it is hoped that the laying of the line on the Chilean side of the Argentine frontier may be finished in 1947, but this depends upon the arrival of 40,000 sleepers, for which transport has not yet been secured. Subject to the ratification of the recent Chile-Argentine Economic Treaty, an agreement has been reached with the Argentine State Railways on a project for the construction of a tunnel on the transandine route, 21 km. in length, which would cut out 80 per cent. of the present extension via Uspallata.

ROOF-TOP ROADWAYS: GENERAL PLAN.*

By WING-COMDR. T. R. CAVE-BROWNE-CAVE, C.B.E., M.I. Mech.E.

AT a conference held by the Engineering Section of the British Association in September, 1946, the various methods of providing additional channels for the rapid flow of traffic in city areas were discussed. The Assistant Commissioner of Metropolitan Police explained that the essential requirement was for traffic channels passing right through the area and capable of allowing traffic to pass at speeds of 40 miles per hour, without interruption from cross-roads or from pedestrians. This system should be connected to the normal traffic system only at intervals of approximately one mile. Papers read to the conference showed that these channels, if constructed below ground level, would involve prohibitive difficulties, because of the confusion which already exists underground and the enormous amount of spoil which would arise. The alternative of providing these channels at road level along the general line of main traffic arteries involves prohibitive expense, by reason of the interference with valuable frontages and the dislocation of traffic in the main arteries while the widening is taking place. To cut new traffic channels along a parallel line, where less valuable frontages are involved, still necessitates crossing many side roads and the interruption of underground services. To carry the new traffic channel on a viaduct at moderate height above the ground avoids certain of these difficulties but involves great expenditure on new construction. There is at the present time an enormous requirement for large buildings going to a height of about 100 ft. All these buildings are of the same general type of construction, based on a steel framework, whether they are to be used for flats, offices, shops or storage.

It was suggested at the conference that the logical means of meeting both these requirements was to build the roadway on top of an almost continuous line of buildings 100 ft. high, with archways over the main thoroughfares, and access spurs at intervals of about one mile. The proposed system appears to have the following advantages. (1) There will be the minimum interference with normal traffic circulation and with existing roads and services. (2) Flow along the new traffic channel will be completely independent of normal traffic circulation at the lower level. (3) The whole of the main structural volume will be available as useful accommodation for flats, offices, shops and storage. Very accessible car-parking space will be available for some 500 vehicles in each spur. (4) The cost of construction will not be greatly in excess of the cost of building an equal volume of 100 ft. buildings of the type for which there is great requirement. The cost of construction would be at least offset by the consequent revenue. (5) It seems probable that the noise of traffic passing along the new roads would be wholly screened, even from the surrounding buildings, by the parapets which would be necessary in any case. Observation shows that, where pneumatic-tyred vehicles only are used, the noise and vibration transmitted through the supporting structure are unimportant. The noise is altogether different from that transmitted in a railway viaduct from steel wheels running on steel rails.

The approaches to the new roadways would be formed as sloping spurs placed at intervals of about one mile and coming conveniently in the space between two existing minor cross roads. It seems reasonable that the gradient of these spurs should be 1 in 10 to 1 in 12, involving a length of about 1,000 ft. in coming down to ground level. Gradients of this steepness are quite satisfactory on many existing main roads and should be quite acceptable for traffic joining or leaving the main viaduct. The sloping spurs seem to offer a convenient opportunity for providing car-garage accommodation on successive floors, say 10 ft. apart. The spurs might be 70 ft. wide with 20 ft. entry at each level between the up and down lanes. Cars would be parked diagonally, with a turning circle at the inner end under the junction of the spur with the main roadway.

The system depends essentially upon the cost and difficulty of constructing the buildings and the roof-top roadway, as compared with that of constructing a similar amount of building to be used only for normal purposes. In the paper reprinted below, Mr. D. H. McPherson shows that there need not be any great departure from normal construction and that the foundation loads would be quite within normal practice. Observations made in the neighbourhood, and actually within the structure of Waterloo Bridge, confirm the conclusion that the noise from traffic overhead would be unimportant. It would certainly be less than that of similar traffic at ground level.

The opinion has been expressed that these viaducts at a height of about 100 ft., with archways spanning each main street, offer great architectural possibilities. The view from them will be much better than that from street level and more intimate and satisfactory than that from aircraft. Such a viaduct might well start from the present blank end of Western-avenue at Shepherds Bush and follow a course lying between Oxford-street and the main-line railway stations to connect with the junction of Mile End and Commercial-roads, or perhaps continuing farther east through the devastated area to the Barking By-pass.

* Paper read before Section G of the British Association, at Dundee on August 29, 1947. Abridged.

ROOF-TOP ROADS: DESIGN.*

By D. H. MCPHERSON, M.I.C.E.

WING-COMMANDER CAVE has presented the general features and advantages of the scheme to provide traffic arteries at roof level. As to the construction of such roadways, at this stage many assumptions have to be made, which may or may not fit in with the scheme were it to be adopted. It has been assumed that the buildings will be 75 ft. wide at roof level and that they will be continuous except where cut by existing ground-level streets, which might be supposed to have a maximum width over pavement of 100 ft.

The height of roof-top roadways above ground level is debatable. The higher they are constructed the more rentable accommodation becomes available, but the length of the approach ramps and the loads on foundations are increased. Taking these into consideration, a roadway level of 100 ft. above ground level would appear to be suitable. The roadway itself would be 60 ft. wide between kerbs, and no footpaths would be provided, since the object of the roadways is to provide traffic arteries, but on each side of the roadway there would be cable ducts, which would be large enough for maintenance staff to walk inside and would have sufficient strength, as a parapet, to prevent traffic, in case of accident, falling to the streets below.

In considering the engineering details of construction, it is necessary to make an assumption regarding the spacing of the main vertical steel columns of the building on which the roadway is supported, and this has been taken as 25 ft. in the directions both longitudinally to the road and across it. In that case, the most suitable form of road construction would appear to be reinforced-concrete slab and longitudinal T beams spanning to either steel or reinforced-concrete cross beams mounted on the tops of the vertical steel columns forming the main framework of the building.

Allowing for Ministry of Transport loading, in addition to the weight of the roadway itself, the maximum load expected at the top of the most highly loaded columns would be about 150 tons. This figure includes dead load, live load and impact, in accordance with current regulations. Where the roadway is carried over an existing thoroughfare, the span necessarily would be increased, and the increased loads to be carried at each end of the span might be offset by closer spacing of the supporting columns so that the load per column could be kept within the figure of 150 tons already mentioned. For spans above about 50 ft., reinforced concrete, in all probability, would be no longer the most suitable material of construction for the main load-carrying girders, and it would be necessary to use steel. The girders under the cable ducts, being more lightly loaded, might be encased in concrete to provide visual continuity of concrete construction.

The loads referred to above would be carried down to foundation level in the normal manner through the steel framework of the building. When the roadway loads are combined with loads from the building itself, the foundation load may be expected to amount to 750 or 1,000 tons, but this is no more than normal for high buildings, and, it may be stressed, requires no departure in construction from normal practice. It may safely be said that, from a constructional point of view, roof-top roads are a feasible proposition.

It has been suggested that the spurs or ramps providing access to the roof-top roads might well provide accommodation under them for parking cars in several storeys. The entrances and exits for these car parks would be in a series up the middle of the roadway and turning circles would be provided at each level, at the end of the spur under the roof-top roadway. Cars would be parked at an angle to the in-going and out-going lanes, a space being left for reversing. Attendants, and some system of colour-light signalling, would be necessary to indicate when a particular storey in the car park is full and where drivers should park their cars. Lifts might be provided to return drivers of parked vehicles to ground level. It is suggested that the car parks under the ramps might have a clear height or headway of 15 ft. for commercial vehicles at ground level, and a clear height of 10 ft. or thereabouts for the remainder.

A gradient of 1 in 12 has been assumed as being reasonable for these approach ramps, although this is a steeper gradient than the maximum recommended by the Ministry of Transport. There are, however, many stretches of roadway built to this gradient which do not appear to inconvenience normal traffic, and the gradient is considered justifiable to avoid unduly long ramps. Generally, the approach ramps would be constructed in series to the left and right of the roof-top roadway, and not immediately opposite each other. Access to and from the spurs would be confined to the adjacent traffic streams; thus, for instance, if we consider a junction between the main artery running east and west and a spur to the north, only traffic from west to east could descend, and traffic ascending the spur, on joining the roof-top roadway, would have to proceed east. Similarly, at a junction with a spur to the south, only traffic from east to west could descend, and ascending traffic would proceed west. This arrangement obviates interrupting the continuous stream of traffic along the artery by the imposition of traffic lights, and should give sufficient facilities for traffic leaving or joining the main artery. If better facilities are required, fly-over junctions could be provided, but these would be complicated and costly to build.

* Paper read before Section G of the British Association, at Dundee on August 29, 1947. Abridged.

INCREASED PRICES FOR GAS AND HARD COKE.—The Ministry of Fuel and Power announces that the works prices of gas and hard coke were increased on Monday, September 15, 1947. Retail prices of coke rose accordingly.

EXAMINATIONS OF THE SOCIETY OF ENGINEERS.—The Society of Engineers announce that the examinations for admission to graduateship and associate membership of that body, which were suspended during the war, will again be brought into operation. They will next be held during the first week of November, 1947, and subsequently in May and November of each year. Further information can be obtained from the secretary, 17, Victoria-street, London, S.W.1.

A NATIONAL RAILWAY MUSEUM.*

By E. W. SWAN, O.B.E.

How is it that this country, the pioneer in the introduction of railways, with all the evolution up to the present day which it has witnessed and the interest which a large section of the public displays in railways, has done practically nothing to possess even one museum devoted to the subject? Some attempts have been made to preserve old locomotives, carriages, books, documents, and equipment of various kinds, by the railway companies themselves. Nearly all of these objects are preserved in the offices or works of the companies and are thus not accessible to the public. The one notable exception is the Railway Museum at York, formed by the London and North Eastern Railway Company. This contains primarily exhibits relating to their own system, or to smaller lines incorporated therewith at various times (for example, the Stockton and Darlington Railway). There are also exhibits, belonging to outside organisations, which have been housed there in the absence of any other or more suitable place, such as locomotives which have been saved from the scrap-heap by the Stephenson Locomotive Society.

Of the museums open to the public, there are only four in the British Isles which contain historic locomotives: the Science Museum, London; the Royal Scottish Museum, Edinburgh; the L.N.E.R. Museum at York; and the Municipal Industrial Museum, Newcastle-on-Tyne. There are, in addition, historic locomotives at railway stations at Darlington, Barrow, and Liverpool. There were carriages at Edinburgh and Waterloo Stations, but these were moved during the war and, presumably, are preserved by the companies elsewhere.

The absence of a national railway museum has frequently been commented on, but, as far as I know, nothing has been done to fill this glaring gap, nor have any such suggestions or proposals been made. It has long been a matter of surprise to foreigners, particularly those interested in railways, and their history and development, to find that this country, which did so much—in fact everything—to build railways, produce the first locomotives, and move passengers, goods, and minerals on a scale never dreamed of before, has never taken the trouble, or seemed sufficiently interested, to form a national museum dealing with the subject.

Unquestionably, railways have been a major factor in advancing the civilisation and development of the whole world. The change due to their advent is comparable to the changes brought about by the steamship, which has enabled man, and materials for his requirements, to be transported quickly, safely, and in large quantities, in vessels of large capacity compared with what was possible in the more picturesque days of sail. Much can be seen all over the country, not only in museums, regarding ships of all kinds, both ancient and modern, and a great many places take a particular interest in preserving records of local types of craft and everything associated with them.

Few people appreciate that, about a century ago, there were some 800 separate railway companies in this country. Many of these were short-lived, gradually becoming absorbed by their neighbours to form the comparatively small number of individual companies which ultimately existed at the time they were "grouped" into four main lines. How little of anything in the shape of records, much less of material objects, exists regarding these early lines to-day. Only a few outstanding locomotives, a few carriages, and practically no early wagons, have been preserved; but there have been hundreds of types of locomotives alone, any one of which would have been worth preserving. All these have gone, with records on paper as the only memorial which we have of them. The most flagrant and least excusable instance of neglect in this respect was surely what occurred at the conversion of the complete broad gauge system of the Great Western Railway in 1892. Not a single locomotive, carriage or wagon was preserved to commemorate one of the most bold and remarkable of all railway enterprises.

Few museums in this country have any railway exhibits; a few have model locomotives, which are always popular, but as often as not they are incorrect in technical details, or not to scale. Abroad, where there is much less railway "background," all the important museums devote considerable space to railways, and many are rich in prints, drawings, photographs, etc., as well. Then there are such museums as the Railway Museum at Nuremburg, entirely devoted to the subject, or the Deutsches Museum at Munich, where railways are dealt with as a main technical subject, along with mining, electricity or any other.

There is much of interest in private hands in this country, particularly books, prints, documents, etc.; two notable collections of this kind have been dispersed in recent years. Ever since railways began, however, no concerted effort has been made at forming any sort of national collection, and it is deplorable to consider not only the amount which has been scrapped, but the number of interesting items which have been gladly snapped up to enrich museums and private collections abroad.

If nationalisation of the British railways is effected, the task confronting the Ministry responsible will be a formidable one. Apart from any other considerations, they will be faced with the task of fusing the existing lines into one system and will have little time to devote to such matters as the preservation of historical items. I see a great danger that priceless records, drawings, etc., may be swept out of works and offices as being of little value to the newcomers in their task. That is true, of course, but these drawings of old types of locomotives, etc., are irreplaceable. It will be seen, therefore, that, particularly in the first years, when so much will be required to make the change-over run smoothly, that it will be very difficult to get anything preserved, or even to get the official authority to do so. These difficulties are increased by the fact that there is no place in which to preserve anything.

It seems to me imperative that no time should be lost in forming a committee to advise on what lines, and where, a national railway museum could be formed; and, further, some consideration might be given to the formation of smaller off-shoots at two or three suitable centres.

This committee, I suggest, would have to consist of representatives of various organisations such as the Government (Ministries of Transport and Education); the four main-line railway companies; the Institution of Mechanical Engineers; the Institution of Locomotive Engineers; the Permanent Way Institution; the Stephenson Locomotive Society; the Museums Association; the railway and technical Press; outside experts on railway history, etc., and any other individuals or representatives of associations whose selection might be agreed on.

This committee would consider the desirability—indeed, the urgent necessity—of forming a museum which would cover the preservation of locomotives, carriages, wagons, permanent way, signals, and all sorts of equipment, photographs, prints, books, records, etc., so as to form a permanent record of railway development. So much has happened in recent years (for example, in electrification and power signalling, to mention two subjects) and much more will follow quickly as soon as conditions permit. All this will mean the replacement of existing apparatus, much of it peculiar to individual lines. Needless to say, much, if not all, will be scrapped and lost irretrievably if some action is not taken in time to prevent it.

There is an equally deplorable absence of any museum dealing comprehensively with land transport, horse vehicles, motor-cars, 'buses, trams, etc. Great changes have occurred in this field in recent years, and, because of the rate at which vehicles, etc., have been scrapped it will be a very difficult matter to form such a museum, at any rate, on the scale that it should be. Some people may think it desirable to form a single Transport Museum; but, while this would naturally be better than nothing I consider that the subjects are too large, and also too distinct, to be treated together. It would require an enormous museum to house both in the manner which the importance of both subjects demands.

The Railway Museum at York, and the various items preserved by the railway companies, are the property of the respective companies. These things may or may not continue to be preserved, should nationalisation take place, but there is no certainty that this will be done. In the case of York, the only actual museum, the building is an old carriage shed, adjacent to other similar buildings. These might be required at any time for railway purposes, particularly if any alteration to the lay-out of the approaches to the main station were to be made. I do most earnestly commend an early consideration of the whole matter; in the first instance, by the Museums Association and its Regional Federations. If it were decided to create a National Railway Museum, I suggest that no place has a stronger claim for consideration than Newcastle-on-Tyne.

* Paper read at a meeting of the Northern Counties Museums Federation, held at Newcastle-on-Tyne, January, 1947. Reprinted from *The Museums Journal*, May, 1947. Abridged.

ASSOCIATION OF SUPERVISORY ELECTRICAL ENGINEERS.—The silver cup, which is awarded annually to that branch of the Association of Supervisory Electrical Engineers having the best all-round record, has been won this year by the West London Branch.

THE ERNST JULIUS COHEN LECTURE.—The Ernst Julius Cohen Memorial Lecture of the Chemical Society, for 1947, will be delivered by Professor F. G. Donnan, C.B.E., D.Sc., F.R.S., at the Society's rooms, Burlington House, Piccadilly, London, W.1, on Thursday, October 2, at 7.30 p.m. The subject of the lecture will be announced later.

RESEARCH ON DOMESTIC HEATING.

SOME particulars of a comprehensive and interesting research on the subject of the effective and economic heating of houses were given at a Press conference on Thursday, September 18, by Dr. F. M. Lea, O.B.E., Director of Building Research, of the Department of Scientific and Industrial Research, Park House, 24, Rutland-gate, London, S.W.7. The importance of the subject will be at once recognised since the most complete figures, namely those for 1938, show that one-third of all the coal consumed in this country in that year, namely, 60,000,000 tons, was used for domestic heating. It will be acknowledged generally that the results of this expenditure of fuel were not satisfactory, much of the available heat being wasted up the chimney, or through poorly insulated walls and roof, or carried off by draughts of cold air. Comparative data show that the heat available in the United States per house per annum is some 13·3 per cent. greater than in Great Britain, but the houses in that country are generally kept much warmer than ours. In Germany, on the other hand, although the fuel consumption is about 41·3 per cent. less than in Great Britain, the houses are at least as warm. A considerable amount of work has been done already in improving the efficiency of domestic heating, but to obtain a precise picture of the thermal conditions in houses as they are lived in has been difficult; to obtain this information, therefore, is the object of the present research.

The experiment now in progress is in two parts. In the first of these, eight houses have been built identical in design but having different degrees of thermal insulation. The heating systems installed are all the same, so that the conservation of heat by varying the types of insulation can be determined under actual living conditions. This group of houses has passed the laboratory stage and they have been lived in by families for over a year. The experiments are still continuing, apart from the preliminary ones made in the unoccupied houses. For the second part of the research, 20 houses of identical size and similar design have been built. In these houses the constant factor is the nature of the thermal insulation, so that the amounts of heat lost through the walls, roofs, floors, etc., will be similar in every case. The variable factor is the method of heating; some of the houses are equipped with complete central-heating systems, others with devices to carry convected heat to the upstairs bedrooms, while all are fitted with a variety of modern designs of stoves and open fires. As in the first part of the research, the first experiments will be made with the houses empty, and a party of 30 scientists and building technicians are now commencing their night and day task of investigating the conditions obtaining under this unoccupied state; the size of this party being due to the desirability of getting through the preliminary work rapidly. As soon as this is completed, tenants, selected by the Rural District Council concerned, in conjunction with the Building Research Station, will move in, their consent to the continuance of the experiments and the presence of the necessary instruments for a reasonable period being a condition of their tenancy. Photographs and plans were displayed at the conference; the houses appear to be of the two-storey semi-detached type and are situated at Abbots Langley, Hertfordshire.

It is, necessary, of course, in view of the variables presented by differences in families, to have a datum. This is fixed by assuming a family consisting of a father, engaged in a local occupation and not returning home at mid-day, a mother in the house all day and two children of school age. The data obtained from this "theoretical" family will be corrected for the size of the family in each house, the hours of work, and so on. It is not practicable to detail the exact procedure of this complex experiment, but a general indication may be given. Each room of each house has a number of instruments, for example, ordinary thermometers and others giving a continuous record over the 24 hours of each day, and recording at a central control room. In the first stage, the ventilation and opening of doors and windows will be carefully controlled so that the conditions between all the houses will be comparable. All the fuel used in each house will be carefully recorded, times of stoking or switching on or off of appliances being noted. In consequence, the amount of heat generated in the house and the amount usefully employed can be determined. In all, 92 different appliances are being tested. There are two meteorological stations which furnish complete data on the weather at the site, such as temperature, humidity, direction and force of wind, and duration of sunshine. As far as we are aware, an experiment of this size and type has not hitherto been embarked upon; it should yield useful results, which, we understand, will be made freely available ultimately to both the building industry and the public. Previously, advice on the best methods of house construction to ensure good heat insulation and on the most efficient heating and ventilating appliances to employ, has had to be based on laboratory methods and experience.

DIESEL-ENGINED LOCOMOTIVE FOR MINES.

THE 100-h.p. oil-engined mine locomotives built by the Hunslet Engine Company, Limited, Leeds, 10, have already been described, on page 404 of our previous volume. Owing to their size they are restricted to the main haulage ways of mines, but the 65-h.p. flameproof locomotive which has been introduced more recently has been designed for the sharp curves and steep gradients usual in British coal workings. It supersedes the company's 50-h.p. locomotive. Although efforts are being made to improve the tracks in British mines, it will be many years before the results become at all general; and in the case of pits where the useful life is now limited to a decade or so, it would be uneconomical to undertake major alterations. The demand for locomotives which will negotiate the severe tracks of old pits will continue, therefore, for some years hence. There is a great variety of track gauges, from about 2 ft. to 3 ft. 6 in., which raises an awkward problem for the locomotive builder, and small-capacity tubs with high rolling-resistance are common. Low axle loads, necessitated by inferior track, and small loading-gauges, are other factors which restrict the design of locomotives for mines.

The locomotive illustrated on this page weighs 10 tons and is built to suit any gauge from 2 ft. to 3 ft. 6 in. It is driven by a Gardner 65-h.p. engine through a two-speed gearbox, giving a tractive effort of 4,500 lb. in first gear at 4½ miles an hour, and 2,250 lb. in second gear at 9 miles an hour. The loads on both axles are the same, and the locomotive may therefore be operated on 35-lb. rails, or even on 28-lb. rails if the sleepers are spaced closely. The locomotive alone will negotiate a 40-ft. radius curve, but when hauling a train the drawgear movement of the tubs and locomotive limits the radius to, in some cases, 75 ft. The tractive effort is limited chiefly by the strength of the draw-gear of existing tubs. A factor of adhesion of 4·25 is considered the minimum for satisfactory working in most pits, but a factor of 5 has been used in this case. As already noted, the engine power has been increased from 50 h.p. in the previous model, to 65 h.p. in the present locomotive. The extra power, however, has been used to increase the speed, in both gears, at which a substantial tractive effort is maintained. The inferior draw-gear of existing tubs will therefore not be over-stressed. The weight of the locomotive (10 tons) is determined by the considerable braking effort, without slipping, which is required for controlling trains on steep gradients. Westinghouse air brakes are provided, and, when the locomotive is coupled to a similarly-equipped man-riding train, safety is ensured on the steepest gradient —1 in 12—envisaged in the Model Code of Regulations of the Ministry of Fuel and Power. The four wheels of the locomotive are 2 ft. in diameter, and the wheelbase is 4 ft. 3 in. The length over buffer beams is slightly less than 13 ft., and the overall width is 3 ft. 10 in.

The main frame of the locomotive is a single casting in high-duty iron weighing about 5½ tons, extending from, and including, the front buffer-beam to the rear buffer-beam, and providing a bed-plate for the engine, the upper half of the gearbox, the driver's well at the rear, the horns for the driving axles, and the upper half of the bearing support for the jack-shaft. Such a heavy casting is necessary for strength to resist the shocks to which the locomotive is subjected, and for adhesive weight. The casing mounted on top of the frame is divided into two parts, fore and aft, which are indicated in the illustration by the separate side covers. The forward half houses the engine, air-compressor, dynamo, and other auxiliary fittings, and the rear half contains the clutch and gearbox in the lower portion, and the Westinghouse-brake cylinders and apparatus in the upper portion.

The Gardner 4LW engine is mounted rigidly at four points on the main-frame casting. The air compressor and radiator fan are driven by belts at the front end of the crankshaft, and a 12-volt dynamo (for the single front and rear headlights) is belt-driven by the radiator-fan shaft. All electrical equipment is made flame-proof to the requirements of the Ministry of Fuel and Power. The radiator, situated at the front of the locomotive, is composed of a number of Serck radiator units mounted between the top and bottom headers, which are fabricated as one member. The engine is started by a Reavell rotary air motor which is mounted on the right-hand side of the engine and drives the flywheel through a Bendix gear. The Westinghouse system operates on air at 80 lb. to 100 lb. per square inch, and the starter motor will operate over the whole of this range. If the air cylinder is empty, it may be filled from the garage or shop air mains, through a connection which is provided on one side of the locomotive for this purpose. A hand starter, turning the crankshaft through a short chain drive, is also fitted above the front buffer-beam.

Two A.C.-Sphinx oil-bath air filters, and two flame-traps, are mounted on the engine inlet manifold, and a water-washing type of exhaust conditioner (including flame-trap) is supported between the frames, immediately behind the front buffer-beam. Similar flame-traps and exhaust conditioners were described in ENGINEERING, vol. 148, page 311 (1939), and it is only necessary to add that, after the exhaust gases have been cleaned, they are discharged in the region of the air which is blown by the fan, so that, when they emerge from the vertical rectangular grille to be seen on the right-hand side of the locomotive, they are diluted and harmless.

The drive from the engine is transmitted by a clutch and two-speed gearbox of the company's own design. Both are operated—to engage or disengage either gear—by a single lever projecting from a large gate, which is shown in the illustration with the lever in the neutral position. A downwards movement of the lever disengages the clutch, then a movement to one side or the other engages the particular gear required; and, by allowing the lever to rise in the slot of the gate under the influence of the clutch springs, the clutch is gradually engaged. A trip mechanism actuates a clutch stop, and releases it, when required. The forward and reverse lever, which also has a central neutral position, may be seen in the illustration, below the two flameproof fuse boxes. The jackshaft is supported in roller bearings, and carries a fly-crank at each end. The length of the jackshaft, the length of the main axles, and the widths between the frames and horns, have to be made to suit the particular track-gauge for which the locomotive is intended. The drive from the fly-cranks is transmitted by two short coupling-rods on each side. The rods have plain bearings, and, in order to exclude dust which would probably enter the conventional type of oil-box which is integral with the rod, lubrication is by heavy gear-oil applied through a grease-nipple at the end of each crank-pin. The only reservoir for the oil is in the longitudinal hole in the crank-pin and the two radial holes which lead off from it to the bearing surfaces, but this is adequate and protects the bearings.

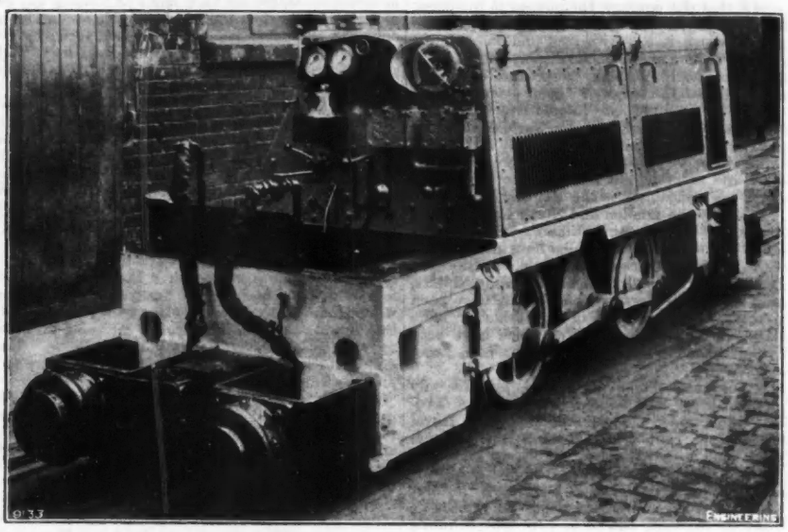
The driving axles and crank-pins are of nickel-chrome steel, and the crankpins are case-hardened. The 2-ft. diameter wheels are of high-duty cast iron, with steel tyres. The axleboxes are bronze with cast-iron keeps and Armstrong oilers. The silico-manganese-steel laminated springs, which are underneath the axleboxes, have 9 plates each, and the top plate is several inches longer at each end than would normally be required. This extra length is bent over at each end, to form a pad of double thickness, which bears on the underside of the horn. As already noted, the horns are integral with the main-frame casting, and in addition to being machined on the inside for the axlebox faces, they are machined on the underside, or foot, to provide a rubbing surface for the springs when they flex. The springs are shackled and coupled to the axleboxes by pins in the usual manner. The horn stay is a steel-plate pressing.

The two-stage air compressor for the brakes is provided with an intercooler, and draws clean air from the induction manifold. The air cylinders and all associated fittings for the Westinghouse brake system are built as an assembly which is erected in, or removed from, the rear half of the casing by coupling or releasing a few pipe connections, supports, etc. There are two air-brake pipe lines, as may be seen in the illustration. One is the normal brake line under the driver's control, and the other is an emergency line, working at 70 lb. per square inch, which may be applied by anyone on a man-riding train, and is also automatically operated in the event of the train breaking in two. The locomotive brakes may also be applied by the hand-lever which is visible in the near corner of the driver's well in the illustration, or by a foot-pedal in the floor of the well. There is one brake block to each wheel, suspended on a hanger, in the front of the front wheels and at the rear of the rear wheels. The pin at the upper end of each front hanger constitutes a fulcrum on the frame. The lower ends of the four hangers are connected transversely by beams and longitudinally by two tie-rods, one on each side immediately behind the wheels; and the brakes are applied, by hand, foot, or air, by a forward movement of the upper ends of the rear hangers. When the brake blocks become worn the pins at the upper ends of the front hangers are removed and inserted in other holes in the frame. The brake gear is adjusted by a left- and right-hand thread mechanism, interposed between the actuating levers and the beam which couples the upper ends of the rear hangers.

In addition to those controls which have already been mentioned, there are several others which may be described. A master air-valve and an air-valve for the starter motor are fitted immediately to the left and right of the rear headlight. There is a compression-release lever for starting, situated at the top left-hand corner of the driver's panel, and this is duplicated at the front of the locomotive for use when starting by hand. The air-brake lever may be seen below the bell, and there are also hand and foot throttles, sanding-gear lever, the air-brake gauges, mileometer, and oil gauge. The buffing- and draw-gear have to be designed to suit each colliery's requirements. The buffers have helical springs, and the draw-gear has a helical spring, or rubber springs if the available space is too small.

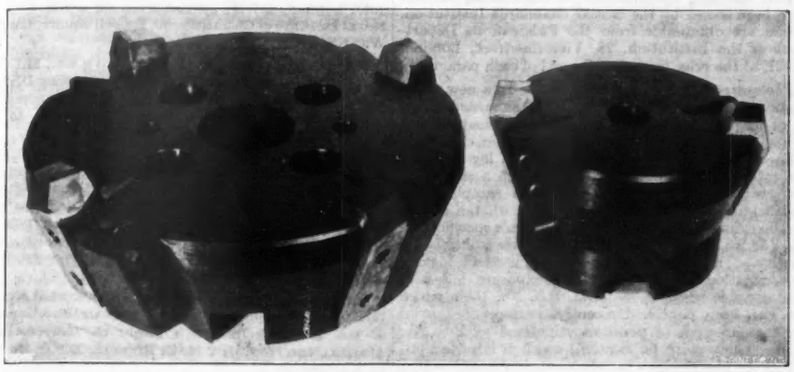
The heads of the bolts which secure such fittings as flame-traps and fuse-boxes are shrouded so that only a box-spanner can be used. This is a requirement of the Ministry of Fuel and Power to ensure that no unauthorised person tampers with the safety of the locomotive. The Hunslet Engine Company are building about 100 mine locomotives, of which 60 for the National Coal Board are similar to the one illustrated and described above.

65-B.H.P. FLAMEPROOF MINING LOCOMOTIVE.



CALEDONIAN RAILWAY CENTENARY.—In connection with the centenary of the opening, on September 10, 1847, of the first section, between Carlisle and Beattock, of the main line of the Caledonian Railway (now part of the London Midland and Scottish Railway Company's system), an exhibition was opened at the Glasgow Art Gallery, Kelvingrove, Glasgow, on September 13, and will remain open to September 29. It includes a collection of models of Caledonian Railway locomotives and rolling-stock from 1880 onwards, and a complete range of illustrations of locomotives from the opening of the line. There are also models of the Caledonian Steam Packet Company's steamers, drawings of engineering works, plans and maps of the railway, time-tables, posters, and other interesting documents.

NEGATIVE-RAKE CARBIDE-TIPPED MILLING CUTTERS.



NEGATIVE-RAKE CARBIDE-TIPPED MILLING CUTTERS.

THE two milling cutters seen in the illustration above have been developed by Messrs. Alfred Herbert Limited, Coventry, to enable users of the older types of milling machine to avail themselves of the advantages of carbide-tipped cutters. These older types of machine are, not uncommonly, of too low a horsepower to allow full advantage to be taken of Messrs. Herbert's standard Carbiface cutters and, moreover, the shops in which they are to be found have not always the necessary facilities for re-grinding the carbide tips. The tool here described is known as the Simpliface cutter, to indicate that it is a simplified version of the Carbiface cutter. The simplification consists of reducing the number of teeth, which reduces also the rate of feed and, therefore, the power absorbed. This follows on the fact that, if ample power is available, and the work can be rigidly clamped, the rate of feed of a milling cutter is proportional to the number of teeth and the power absorbed varies, roughly, in the same proportion. The reduction in the number of teeth does not, however, remove the grinding difficulties referred to earlier but in the Simpliface cutter the blade tips are formed and mounted so that they can be readily re-ground by hand before insertion in the cutter body, care being taken to maintain the same angles on each blade. Should a surface grinder be available, the cutting angles can be machine-ground, the blades being held either in a swivel vice or on a faceted block with the appropriate angles machined on its faces. It will be appreciated that the Simpliface cutter is not intended to be used as an alternative to the Carbiface cutter; it is a tool designed to suit the particular conditions obtaining with low-powered machines.

The Simpliface cutter is manufactured in four sizes, 9 in., 7 in., 5 in. and 3 in. in diameter, respectively, the two largest having four blades, as shown at the left of the illustration and the others having two, as shown at the right of it. Blades are available in two types and four sizes. The types have, respectively, Ardoloy S.200 grade tips with 10 deg. negative radial rake combined with 10 deg. negative axial rake for milling steel, and the same grade tips with 10 deg. positive radial rake and 10 deg. negative axial rake, for milling cast iron or normal non-ferrous materials. Either type of blade can be used in the one type of body of the correct size since the rake angles are embodied entirely within the blades and the body slots are of the same shape and size throughout. The blades each have two socket-head screws, visible on the backs, and three securing screws in the body lugs. The ends of the two screws through the blade shank form abutments at the bottom of the blade slots in the cutter body.

In setting the re-ground blades, no setting gauge is necessary since the work to be machined itself acts as a gauge. The cutter body, with one blade securely clamped in position, is first mounted on the machine spindle and a cut approximately 1 in. long by $\frac{1}{4}$ in. deep is taken, at a fine feed, across the first component. The feed and spindle are then both stopped. Another blade is then placed in the body slot and is set to bear lightly on the small area milled by the first blade. The second blade is lightly clamped by the three securing screws and then the blade-shank screws are tightened to bring the lead angle of the blade into contact with the angular surface at the run-out of the cut left by the first blade. The final process consists of the rigid locking of the three securing screws, followed by an extra turn to the blade-shank screws to prevent loosening during the cut. The same procedure is repeated until all the blades have been secured and, if the work has been done carefully, all the blades should follow the same track within approximately 0·002 in. on both the face and the periphery.

It might be objected that to reduce the number of teeth in a milling cutter, as is done with the Simpliface cutter, will cause violent fluctuations of load as the individual teeth go into and out of action. It is well known that an ordinary flycutter must be fed very slowly and with shallow cuts in order to limit the shocks to which it is subjected in use. This drawback has been minimised by the introduction of the carbide-tipped milling cutter, which can be used at very much higher cutting speeds than were previously possible. The increased speed automatically increases the fly-wheel effect of the rotating machine elements and the extra energy thus stored tends to damp out the fluctuations of load on the milling cutter with few teeth. In fact, carbide-tipped cutters having from one to four teeth can now be rated as production tools. At the same time, it is advisable, wherever possible, to increase the amount of stored energy by the employment of flywheels with all Ardoloy-tipped milling cutters; particularly is this the case with cutters having few teeth.

THE INSTITUTE OF MARINE ENGINEERS; PRESIDENTIAL ADDRESS*.

By SIR AMOS L. AYRE, K.B.E., D.Sc.

THE building of ships and their engines has not, in past experience, been an industry free from anxiety. No other industry has known such violent fluctuations in the course of the trade cycle. We have had the bitter experience, as recently as 1933, of a demand for our services in shipbuilding and marine engineering falling as low as only about 5 or 6 per cent. of the capacity of the available physical means of production. The shipping industry has also experienced severe fluctuations resulting, from time to time, in abnormal amounts of tonnage having to be laid up. Inability to sell abroad our staple product, coal, has brought about an increasing proportion of ballast voyages. This is not the time to prophesy slumps, but it is the time to consider the possible ultimate post-war condition and to benefit from the experiences that followed the short period of high demand after the 1914-18 war.

The extent of thought, study, research and the long hours given to the various subjects presented to this Institute for consideration, and to the many other scientific societies, is such that one wonders if the part played by such institutions in the great and vital interest of our industries, and of their maintenance and expansion, is generally realised. The opportunity so provided for discussion and collective thought has, in fact, a most valuable effect on the economics of this nation, in which the scientific institution has been so long and closely linked with industry.

In these days, those whose lives are given to the application of science in the technical and practical planning and development of industry have frequently to listen to others whose experience and current interest is only academic or political and who are without any knowledge of the technical problems of production, but would, nevertheless, direct how things should be planned and done. Some of them should examine the transactions of our scientific institutions to obtain a general indication of the vital background of all industry, and the real dependence of each industry on those who, by hard work, learning, training, and experience, have attained the qualification technically to direct and administer. As in the case of all national industries, such outside critics would be surprised to learn of the thought and care which are given to the science and practice of marine engineering, and the time that is given to its constant development, under conditions in which shorter working weeks do not apply, in the effort to keep abreast of the times. It is usually a condition of continuous intensive study in the solution of problems throughout a seven-day week and with the aid of much "midnight oil." Without such devotion, industry could not, in fact, develop and prosper.

If nationalisation of some of our industries is to be successful, those who bring it about must have regard to such features. Merely to have had experience in a sectional part of an industry is not sufficient; it is vitally essential that those who are put in the new positions of authority must have had comprehensive training, experience and proved ability. Without such attributes—which means full scientific knowledge covering the design of the particular product, all the technical and economic ramifications of its production, the commercial aspects which commence with the purchase of the raw materials, and, finally, the selling of the product in the world's markets—those who are put in authority must inevitably fail, with disastrous consequences nationally. British industry has a valuable goodwill in many export markets, in that considerable faith is held in the dependability that can be placed on British technical knowledge and ability, derived from intensive study and research and from personal enterprise and initiative. Should the newer methods of dealing with the administration of basic industries destroy that enterprise and initiative of the individual, it will be a sorry day for this country.

The wealth of a nation normally lies in the products of agriculture or mining. We have nothing of an agricultural nature to export and, in fact, fall far short of feeding ourselves. The coal which was hewn in excess of home needs used to be a most valuable export and went a long way in paying for imported food. This condition of exchange no longer applies and we are, therefore, left with practically only two outstanding means with which to meet our foreign payments, these being manufactures, many of which depend on imported raw materials; and the various services performed for other nations, usually termed "invisible exports," to which shipping normally makes a most important contribution. Our present inability to export coal requires every effort to be made to increase the two remaining principal items. If we are to maintain our existence on this densely populated island, there must be, without further delay, a keen recognition by all of the hard fundamentals of our national economy. We must re-assert our British initiative, enterprise and adventure. Those in positions of leadership must realise their serious responsibility and boldly tell the naked truth to those they lead. There are many to-day, carrying what may turn out to be a terrible responsibility, who should pause to think where, apparently for the sake of temporary popularity, they are leading.

We have heard much about the vital need to increase the volume of exports, but little regarding the ultimate dependence of the ability to export upon the price of the products. If production costs, compared with those of competitors, are too high, the volume will fall. It is this feature on which emphasis should be placed as the first rational step towards the effort to increase the volume of our exports. Steps should be taken now to prepare against the universal condition of a buyer's market that will inevitably emerge, perhaps as suddenly and unannounced as it did after the first world war. The elementary fact that this country's ability to support its relatively large population depends on efficient and economical production must be realised by all if we are to survive.

The effect of a shorter working week also calls for very serious thought. Even with the 47-hour week, assuming no absenteeism, the capital assets of plant, building and machinery, in an industry working on a one-shift basis, were only in operation for 28 per cent. of the total time available. A week of 44 hours reduces the net time to 26 per cent. Productive plant that now ceases its five-day operation on a Friday evening remains dormant for over 60 hours before the restart on Monday. Under such conditions there is the need more than ever to make the fullest use of methods of production, based on the scientific researches and studies of those whose responsibility it is technically to direct, and all traditional restrictions should make way for their introduction.

At the same time, invisible exports become more than ever important. It is remarkable that, among all the speeches and debates about the need to redress the balance of trade, nothing has been developed regarding the advisability of extending to the utmost the contribution of our shipping services. It is sad to think that, because of the shortage of materials, deliveries of new ships during the twelve months to June 30, 1947, fell short of the programme which the industry had planned, by more than half a million gross tons. In the succeeding twelve months, the fall will

* Delivered at the Institute, the Minories, London, E.C.3, on Tuesday, September 9, 1947. Abridged.

be even greater unless there is an immediate improvement in all supplies. In 1939, the United Kingdom's portion of the world total of tonnage afloat was about 26 per cent. It is now only about 20 per cent., while more and more countries, whose fundamental economics do not lend themselves to engaging in maritime transport, nevertheless pronounce their intentions of building up merchant fleets capable of carrying much of their imports and exports under their own flags, thus preventing the countries that now provide the maritime transport from earning the foreign exchange with which to buy the products that the other nations have to sell.

LAUNCHES AND TRIAL TRIPS.

M.S. "CROSBIAN."—Twin-screw cargo vessel, built by Messrs. William Gray and Company, Limited, West Hartlepool, for Messrs. Ellerman Lines, Limited, London. Main dimensions: 255 ft. by 42 ft. by 25 ft. to shelter deck; deadweight capacity, 1,780 tons on a draught of 17 ft. Two 960-brake horse-power Polar Diesel engines, supplied by Messrs. Atlas Diesel Company, Limited, and installed by the Central Marine Engine Works of Messrs. William Gray and Company. Trial trip, September 3.

M.S. "CORAMBA."—Single-screw refrigerated and general cargo vessel, built by Messrs. Short Brothers, Limited, Pallion, Sunderland, to the order of the Australasian United Steam Navigation Company, Limited, London and Sydney. Main dimensions: 360 ft. overall by 51 ft. 9 in. by 34 ft.; deadweight capacity, 5,500 tons on a mean draught of 22 ft. 7 in. Four-cylinder opposed-piston two-stroke oil engine supplied by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, to give a service speed of 12 knots. Launch, September 5.

M.S. "AENEAS."—Single-screw cargo liner built by The Caledon Shipbuilding and Engineering Company, Limited, Dundee, to the order of Messrs. Alfred Holt and Company, Liverpool, for the Ocean Steamship Company, Limited. Main dimensions: 450 ft. by 62 ft. by 35 ft.; deadweight capacity, 9,300 tons. Harland-B. and W. eight-cylinder double-acting two-stroke Diesel engine of 7,500 brake horse-power, supplied by Messrs. Harland and Wolff, Limited, Belfast, to give a service speed of 16 knots. Trial trip, September 10.

S.S. "BRANKSOME."—Single-screw collier, built by Messrs. S. P. Austin and Son, Limited, Wear Dockyard, Sunderland, to the order of Messrs. Stephenson, Clarke and Associated Companies, Limited, London. Main dimensions: 240 ft. by 36 ft. 7 in. by 16 ft. 7 in.; deadweight capacity, about 1,900 tons. Triple-expansion engine supplied by the North Eastern Marine Engineering Company (1938), Limited, Sunderland. Launch, September 15.

S.S. "PRESIDENT DE CAZALET."—Twin-screw passenger and cargo vessel, built and engined by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Walker, Newcastle-upon-Tyne, to the order of the French Government for the Compagnie de Navigation Mixte, Marseilles. Main dimensions: 402 ft. overall by 53 ft. 6 in. by 27 ft. 3 in., deadweight capacity, 1,850 metric tons on a mean draught of 19 ft. 5 in. Parsons-type single-reduction geared turbines, with two Lamont oil-fired boilers supplied by Messrs. John Thompson Watertube Boilers, Limited, Wolverhampton. Launch, September 15.

M.S. "DAUNTLESS STAR."—Single-screw drifter-trawler, built by Messrs. Cochrane and Sons, Limited, Ouse Shipbuilding Yard, Selby, Yorkshire, for the Star Drift Fishing Company, Limited, Lowestoft. Main dimensions: 96 ft. by 21 ft. by 10 ft. Diesel engine supplied by Messrs. Crossley Brothers, Limited, Openshaw, Manchester. Launch, September 16.

M.S. "ACHILLES."—Single-screw cargo liner, with accommodation for 12 passengers, built by The Caledon Shipbuilding and Engineering Company, Limited, Dundee, to the order of Messrs. Alfred Holt and Company, Liverpool, for the Ocean Steamship Company, Limited. Main dimensions: 450 ft. by 62 ft. by 35 ft.; deadweight capacity, 9,000 tons. Eight-cylinder double-acting two-stroke B. and W.-type Diesel engine of 7,500 brake horse-power, supplied by Messrs. John G. Kincaid and Company, Limited, Greenock, to give a service speed of 16 knots. Launch, September 16.

M.S. "STAR OF SCOTLAND."—Trawler, built by Messrs. Hall, Russell and Company, Limited, York-place, Aberdeen, for the Walker Steam Trawl Fishing Company, Limited, Aberdeen. Main dimensions: 125 ft. by 24 ft. 6 in. by 13 ft. 9 in. Diesel engine of 700 brake horse-power supplied by British Polar Engines, Limited, Govan, Glasgow. Trial trip, September 17

S.S. "GODANES."—Trawler, built by Messrs. Cook, Welton and Gemmell, Limited, Beverley, East Yorkshire, to the order of the Icelandic Government. Main dimensions: 175 ft. by 30 ft. by 16 ft.; gross tonnage, about 650. Triple-expansion engine supplied by Messrs. Charles D. Holmes and Company, Limited, Alfred-street, Hull. Launch, September 17.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Photographic Transmission Density.—In a new specification, B.S. No. 1384-1947 covering the measurement of photographic transmission density, issued by the British Standards Institution, transmission density is defined in general terms as the common logarithm of the ratio of the radiant flux incident on a sample to the radiant flux transmitted by the sample. The specification has been made uniform with the corresponding American Standards Association's specification No. Z38.2.5/161-1946, dealing with diffuse transmission density. The new British Standard method for the determination of the speed and exposure index of photographic negative material, B.S. No. 1380, which has also been published recently, is dependent upon the measurement of densities stipulated in B.S. No. 1384. The present publication, which is intended primarily for photography in monochrome, recognises that there is no unique method of density measurement which is universally applicable and gives, in some detail, a classification of the various types of density occurring in practice. It is emphasised that variations in the geometrical arrangement of the optical system give rise to a number of geometric types of density which generally lead to different numerical density values. Among these are three distinct and fundamental types, namely, diffuse density, specular density and doubly-diffuse density, all of which are precisely defined in the specification. As, however, inert densitameters are calibrated in terms of diffuse density, which is usually employed in expressing the characteristics of photographic materials, this type of density has been specified in detail in the present publication. [Price 4*s.*, postage included.]

Copper Tubes.—A revision of that portion of B.S. No. 61-1913 concerning heavy-gauge copper tubes for general purposes has been prepared and issued as B.S. No. 61-Part 1-1947. The threading details are published separately as B.S. No. 61-Part 2, entitled "Screw Threads for Copper Tubes." In preparing the revision of Part 1, account has been taken of the fact that the specification has become well established, and as much of the original has been retained as is consistent with the requirements of effective revision. The thickness of the tubes has been co-ordinated with other specifications in order to simplify the range of copper tubes recognised as standard. As a result of this, Table 1 in the previous edition, for the lowest pressure pipes, has been omitted, and Tables 2 and 3 are superseded by Table 1 and 2 of the new edition. These deal with the dimensions, thickness and weight of tubes for pressures up to and including 175 lb. per square inch (Table 1) and for pressures over 175 lb. and up to and including 300 lb. per square inch (Table 2). In addition, a number of slight alterations have been made to the outside diameter of the tubes and clauses covering chemical tests, inspection, testing facilities, and additional tests before rejection, have been added. [Price 2*s.*, postage included.]

BOOKS RECEIVED.

Ministry of Works. Post-War Building Studies. No. 26. *Domestic Drainage.* By the Plumbing Committee of the Building Research Board of the Department of Scientific and Industrial Research. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

The Simon Engineering Group. Published for Henry Simon Limited and Simon-Carves Limited, Cheadle Heath, Stockport, by the Northern Publishing Company, Limited, 37, Victoria-street, Liverpool 1. [Price 5*s.*, post free.]

Aircraft Engines of the World, 1947. By PAUL H. WILKINSON. Paul H. Wilkinson, 216, East 45th-street, New York, U.S.A., and Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 50*s.* net.]

Geological Structures and Maps. A Practical Course in the Interpretation of Geological Maps for Civil and Mining Engineers. By A. ROBERTS. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

Highway Engineers' Reference Book for County and Municipal Engineers, Civil Engineers and Contractors. Advisory editor: EDWARD STEAD. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 30*s.* net.]

Aerodynamics. By PROFESSOR LESLIE R. PARKINSON. The Macmillan Company, 60-62, Fifth-avenue, New York City, U.S.A. [Price 2.20 dols.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 11*s.* net.]

PERSONAL.

SIR ARTHUR J. G. SMOUT, J.P., director of Imperial Chemical Industries, Limited, Nobel House, Buckingham-gate, London, S.W.1, has been elected a fellow of the Royal Institute of Chemistry, 30, Russell-square, London, W.C.1.

MR. G. A. HANKINS, D.Sc. (Eng.), Wh.Ex., M.I.C.E., M.I.Mech.E., Superintendent of the Engineering Division of the National Physical Laboratory, has been appointed Director of Mechanical Engineering Research to the Department of Scientific and Industrial Research.

MR. H. G. TAYLOR, D.Sc. (Eng.), D.I.C., M.I.E.E., F.Inst.P., formerly technical adviser to Messrs. Philips Industrial, and manager of the industrial development department of Messrs. Philips Lamps Limited, has been appointed director of research to the British Welding Research Association, 29, Park-crescent, London, W.1, to succeed MR. A. RAMSAY MOON, who has resigned, as stated on page 130, *ante*.

CAPTAIN W. G. ANDREWS, C.B.E., D.S.O., R.N., has been appointed senior naval member of the directing staff of the Imperial Defence College, to succeed REAR ADMIRAL THE HON. GUY H. E. RUSSELL, D.S.O., to date from December 8.

LIEUT.-COLONEL KEITH BRINSMEAD, D.S.O., M.I.C.E., A.C.G.I., has been promoted to the position of Permanent Way Engineer (Railways) to the London Passenger Transport Board.

MR. HENRY LAKE has resigned his position with the Ministry of Aircraft Production at Birmingham, and has been appointed technical representative of Messrs. R. Ramsden and Son, Limited, Shinstone Works, Grange-road, Leyton, London, E.10.

MR. E. S. HART, B.Sc., A.R.S.M., has been appointed chief superintendent of the order and planning department of the British Aluminium Company, Limited, at Falkirk, Stirlingshire.

MR. G. ARCHER, formerly in charge of the Directorate of Non-Ferrous Metals at the Ministry of Supply has joined the staff of the Mond Nickel Company, Limited, Grosvenor House, Park-lane, London, W.1, with effect from September 15.

DR. M. BALICKI has left England to take over the duties of his appointment as assistant professor at the Brooklyn Polytechnic Institute, 99, Livingstone-street, Brooklyn, 2, New York, U.S.A., with effect from September 1.

MR. HORACE W. CLARKE has been re-elected President of the British Non-Ferrous Metals Federation, 18, Bennett's-hill, Birmingham, 2, to hold office for the year 1947-48. MR. W. H. HENMAN has been elected vice-president of the Federation.

MISS J. U. SPELLMAN, who was formerly in charge of the research-department library of Messrs. Electrical and Musical Industries, Limited, has been appointed librarian to the Copper Development Association, Kendals Hall, Radlett, Hertfordshire.

LIEUT.-COLONEL MAURICE ORMONDE DARBY, O.B.E., is resigning his position as aero sales manager in London to Messrs. Rolls-Royce Limited, Derby, at the end of September and is retiring from active business life. He has been with Messrs. Rolls-Royce for 13 years.

MR. A. L. MACKILLOP, director and joint general manager of Messrs. C.A.V., Limited, Worple-way, Acton, London, W.3, is retiring at the end of September, after 17 years' service with the company.

The firm of ZIRCONAL LIMITED, has been formed in conjunction with SILICON (ORGANIC) DEVELOPMENTS LIMITED, 11, Cavendish-place, London, W.1, as a production unit for the manufacture of synthetic mullite and zircon refractory compounds, using the Silester bonding process.

THE STEEL COMPANY OF WALES, LIMITED, Port Talbot, and MESSRS. JOHN LYSAGHT, LIMITED, Bristol, have entered into an agreement whereby Messrs. Lysaght's Orb Works at Newport, Mon., will be transferred entirely to a new company to be known as THE STEEL COMPANY OF WALES (LYSAGHT WORKS), LIMITED. The new company will be a subsidiary of the Steel Company of Wales, Limited, and will take over all Messrs. Lysaght's contracts in respect of the transferred Orb Works as from September 28. Messrs. Lysaght will carry on their offices and works at Bristol, Scunthorpe and London as previously, and their London office at 66, Cannon-street, E.C.4, will continue to deal with the products of the Newport works.

A new company, to be known as BRITISH AMERICAN RESEARCH, LIMITED, has been incorporated in Scotland, promoted jointly by the National Research Corporation, 70, Memorial-drive, Cambridge, Mass., U.S.A., and Messrs. Daniel Varney, Limited, 23, Portman-close, London, W.1. The new company will manufacture and sell the industrial high-vacuum equipment developed by the National Research Corporation, and will serve them in a liaison capacity respecting technical developments in Great Britain and Europe.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Outputs of steel have been well maintained during the past week, and although not quite up to the full capacity, on account of small furnace and other difficulties, the level still nearly reaches the 39,000-ton mark. A special effort has been made to increase supplies of plates, particularly thin plates, and consequently users have benefited from moderately high deliveries. The shipyards obtained slightly better deliveries and their repair and overhauls branches were notably well placed for steel, priority being given to this type of work in the yards on account of the material relief it affords to the shipping shortage at a small cost in materials. Tube and sheet makers are overwhelmed with home and export business, and allocations to users have had to be made sparingly. Re-rollers are still finding great difficulty in procuring billets and other semi-finished materials, and their rolling programmes have been restricted accordingly. The growing shortage of steel scrap is hampering makers. Home scrap has fallen off sharply and imports are only about one-third of their pre-war volume. There is apparently great difficulty in getting more pig iron to balance the position owing to the strictly limited supply of hard coke available throughout the country for the new blast-furnaces now ready to start. The problem of coke calls for more coke-making plant and more coking coal, and neither of these is likely to be met quickly or effectively.

Scottish Coal.—Supplies of coal have been steadier in Fife, Lothians, and Ayrshire, but Lanarkshire's output is still suffering from spasmodic stoppages in the Blantyre district. The demand is still at the low summer level, and immediate needs are being covered without difficulty. Stock targets of gasworks and electric power stations are now being approached, and industry, on the average, is better placed than it was this time last year; some engineering works are well stocked. House-coal reserves in depots, however, remain disappointingly low. Weekly outputs, at about 440,000 tons, are considerably short of the Scottish weekly target of 500,000 tons, and such an output, it is estimated, will prove quite inadequate when winter conditions begin. There is no coal for export. Hard-coke supplies are scarce, and negotiations have been proceeding for some months to surmount the difficulty arising from this shortage, more especially as the blast-furnace capacity will not be utilised fully unless coke is forthcoming.

Scottish Shipbuilding.—Shipbuilders generally have been cheered by the news that their industry is to qualify for priority in steel. They expect that this will apply more particularly to the ships they have in hand for foreign owners, representing about 28 per cent. of the total tonnage now building in this country. Norway is Britain's largest shipbuilding customer at the moment, and 15 foreign countries in all have placed orders with Scottish and other shipbuilding concerns. A prominent Clyde shipbuilder stated last week that he expected there would be some increases in the price of new ships, because extra charges would probably be made in the course of the next year or so for coal, steel, and electricity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Pig-iron is coming forward fairly freely now that coking plants are operating at full heats. It will be some time before steelmakers and steel users recover from the effects of the fuel restrictions during the period of the miners' strikes. The complete cut in gas forced many furnaces to close down, chiefly heat-treatment furnaces, but there has been a week of supplies at about 90 per cent. of normal, with a promise of full supplies in the near future. It is understood that dearer coal and higher freights are to result in an increase in the cost of gas. Steelmakers and makers of steel products report the serious disorganisation of their delivery programmes, and higher prices in most cases. The sellers' market overseas continues to decline. Agricultural-steel firms are trying to respond to the urgent demands for machine parts and edge tools for the new season, but have made a bad start owing to fuel shortage. Engineers' small tools continue to be in very heavy request, and all tool factories have many months' work on hand.

South Yorkshire Coal Trade.—American coking coal directed to North Lincolnshire coke works has permitted fuller supplies of Yorkshire coal to reach Yorkshire coke-ovens, which, with full coal allocations, are now operating at full heats. More coke is available, and supplies of coke-oven gas are approaching normal. South Yorkshire collieries which were affected by the strikes are now producing normal outputs and supplying large quantities of washed and graded steams for industry and the railways. Washery fines are being offered freely for firing Lancashire boilers. House coal is in short supply, partly owing to some qualities having been directed to gasworks during the dispute.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Changes in the iron and allied trades on Tees-Side are for the better, but a feeling of uncertainty concerning the near future still prevails. A welcome improvement in the fuel situation can be reported, but the requirements of consumers are enormous and fear is expressed that coal and coke deliveries will not be adequate. The output of Cleveland ironstone remains at a low level, but imports of high-grade foreign ore are maintained on a satisfactory level and parcels of native ironstone from mines at a distance are regularly reaching works in the Middlesbrough area. Although there are still complaints of the shortage of pig iron, the scarcity is becoming less acute and an expansion in production is promised later. The bulk of the extra tonnage is required in the melting shops. Better deliveries, however, are also expected for the foundries, where full operations have been impossible for some time owing to the shortage of pig iron and scrap. All steel-producing plants, on the North East Coast, are running at as high a pressure as conditions permit, but outputs still fall short of customers' urgent needs.

Foundry and Basic Iron.—Increasing quantities of high-phosphorus pig iron are going into use, but still larger deliveries would be welcome. The moderate local make is rapidly absorbed and the larger parcels coming to hand from elsewhere are quickly taken up. Basic iron is unobtainable; the whole of the make is passing into direct use at the producers' adjacent steel plants.

Hematite, Low-Phosphorus and Refined Iron.—Sales of East-Coast hematite are extensive, but makers are able to deal satisfactorily with their delivery obligations. Low- and medium-phosphorus grades of iron are in better supply than of late, but users are still demanding larger quantities.

Manufactured Iron and Steel.—Manufacturers of semi-finished and finished iron are handling substantial contracts and steel producers have embarrassingly large bookings. Users of steel semies are unable to cover their requirements by the tonnage available of home-made commodities and are buying Continental material. Prime sheet bars and billets, in particular, are wanted in large quantities by re-rollers. The demand for all descriptions of finished steel is still intense, both for home purposes and for shipment overseas, and the increase in exports, which is an integral part of the Cripp's plan, must entail further restrictions in the much-needed supplies to home customers. Manufacturers of plates, sheets, sections, joists and all classes of railway requisites are unable to cope with the work they have in hand.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—In spite of improvements in the output from the South Wales mines, following the conclusion of the staggered holidays, it was still considerably short of the target of 500,000 tons a week, which was fixed early this year by Mr. Shinwell. The latest figures available show that it rose from 395,000 tons in the week ended August 30, to 408,200 tons in the week ended September 6, while provisional figures for the week ended September 13 place production at 413,300 tons of saleable coal raised. It was revealed during the week, by Gen. Sir Reade Godwin-Austin, chairman of the Divisional Coal Board, that whereas the Division should have produced 10,629,000 tons towards the target of 200,000,000 tons set up for the country by the Government, the actual production had been only 9,923,000 tons. To make good the deficit of 906,000 tons would necessitate an average weekly production of 600,000 tons of coal raised and weighed. For this to be secured, an effort far in excess of any in recent times would have to be made. The supply of coal on the Welsh steam-coal market was very restricted during the past week. The demand from home sources was well maintained and, with only limited quantities available for some time to come, operators had to scrutinise all orders carefully before concluding business. As a rule, order books were already sufficiently well filled with business from the public-utility and other high-priority undertakings to account for almost the whole of potential outputs for a long time ahead. Exports continued to be almost entirely impossible to arrange, in spite of the fact that considerable interest was shown by some foreign buyers. Limited quantities of the poorest sorts were available for delivery to Eireann users and some anthracite was spared for Canada. Otherwise, foreign trade was in abeyance.

THE ROYAL AERONAUTICAL SOCIETY.—The next associate-fellowship examination of the Royal Aeronautical Society will be held about the middle of December. Application forms are obtainable from the secretary of the Society, Captain J. Laurence Pritchard, 4, Hamilton-place, London, W.1.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF ECONOMIC ENGINEERING.—*London Region:* Sunday, September 28, 2.30 p.m., Waldorf Hotel, Aldwych, W.C.2. "Reflections on Productivity Assessment," by Mr. J. Burgess. *Midland Region:* Saturday, October 4, 2.30 p.m., Chamber of Commerce, 95, New-street, Birmingham, 2. "Time Study Allowances," by Mr. S. Walford.

ROYAL UNITED SERVICE INSTITUTION.—Wednesday, October 1, 3 p.m., Whitehall, S.W.1. "Higher Training for Combined Command," by General Sir William Slim.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Tees-Side Sub-Centre:* Wednesday, October 1, 6.30 p.m., Cleveland Scientific and Technical Institute, Middlesbrough. Chairman's Inaugural Address, by Mr. E. H. Jordan. *Southern Centre:* Wednesday, October 1, 6.30 p.m., Council Chambers, Southsea. Chairman's Inaugural Address, by Mr. D. D. Rayner. *Rugby Sub-Centre:* Wednesday, October 1, 6.45 p.m., Corporation Electricity Showrooms, Rugby. Chairman's Inaugural Address, by Mr. H. G. Middleton. *Mersey and North Wales Centre:* Monday, October 6, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Chairman's Inaugural Address, by Mr. P. C. Barnes. *Institution:* Thursday, October 9, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Presidential Address, by Mr. P. Good.

ROYAL STATISTICAL SOCIETY.—*Industrial Applications Section:* Wednesday, October 1, 6.30 p.m.; Chamber of Commerce, 95, New-street, Birmingham, 2. "Economics Statistics," by Mr. F. A. Friday. Friday, October 3, 6 p.m., 2, Savoy-hill, London, W.C.2. "The Organisation of a Market Research Department," by Mr. A. S. Wharton.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, October 1, 7 p.m., James Watt Memorial Institute, Birmingham. Annual General Meeting. *Institution:* Friday, October 3, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. A series of questions for general discussion.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Eastern Graduates' Section:* Saturday, October 4, 2.30 p.m., Gas Showrooms, Grainger-street, Newcastle-upon-Tyne. Chairman's Address, by Mr. R. Stewartson. *London Graduates' Section:* Saturday, October 4, 3 p.m., Storey's-gate, St. James's Park, S.W.1. "A Survey of Combustion Research as Applied to the Internal-Combustion Engine," by Mr. W. P. W. Moore. *North-Eastern Branch:* Monday, October 6, 6 p.m., Neville Hall, Newcastle-upon-Tyne. Joint Meeting with the INSTITUTION OF ELECTRICAL ENGINEERS (*North-Eastern Centre*). Repetition of Parsons' Memorial Lecture on "Parsons: The Man and His Work," by Sir Claude D. Gibb. *Automobile Division:* Tuesday, October 7, Storey's-gate, St. James's Park, S.W.1. 5.30 p.m., Annual Meeting. 6 p.m., "Some Notes on the Design, Development, and Production of High-Speed Compression-Ignition Engines," by Messrs. S. Markland and N. Tattersall.

INSTITUTION OF PRODUCTION ENGINEERS.—*Yorkshire Graduate Section:* Saturday, October 4, 2.30 p.m., Great Northern Hotel, Leeds. "Production Control," by Mr. J. P. Kenyon. *Yorkshire Section:* Monday, October 6, 7 p.m., Hotel Metropole, Leeds. "Noise and Vibration in Machinery," by Dr. W. A. Tuplin. *Manchester Graduate Section:* Tuesday, October 7, 7.15 p.m., College of Technology, Manchester. "Automatic Bar Lathes and Their Operation," by Mr. H. Butterworth.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lancashire Branch:* Saturday, October 4, 3 p.m., Engineers' Club, Manchester. "Laboratory Control in a Light-Alloy Foundry," by Mr. E. J. R. Mitchell. *Wales and Monmouth Branch:* Saturday, October 4, 6.30 p.m., Engineers' Institute, Park-place, Cardiff. "Gating and Risering of Iron Castings," by Mr. G. L. Jones. *Sheffield Branch:* Monday, October 6, 7.30 p.m., Royal Victoria Hotel, Sheffield. Presidential Address on "Economic Aspects of the Foundry Industry," by Mr. B. Gray.

LONDON ASSOCIATION OF ENGINEERS.—Saturday, October 4, 6.30 p.m., Charing Cross Hotel, Strand, W.C.2. "Chemistry as a Tool for the Engineer," by Mr. R. A. Rabnott.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 7, 6.30 p.m., 39, Elmbank-crescent, Glasgow. Presidential Address by Dr. J. M. McNeill.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Thursday October 9, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Bogies and Pony Trucks: Their Behaviour on the Locomotive and the Track," by Mr. J. C. Loach.

FLYING DISPLAY OF BRITISH AIRCRAFT AT RADLETT.

(*For Description, see Page* 303.)

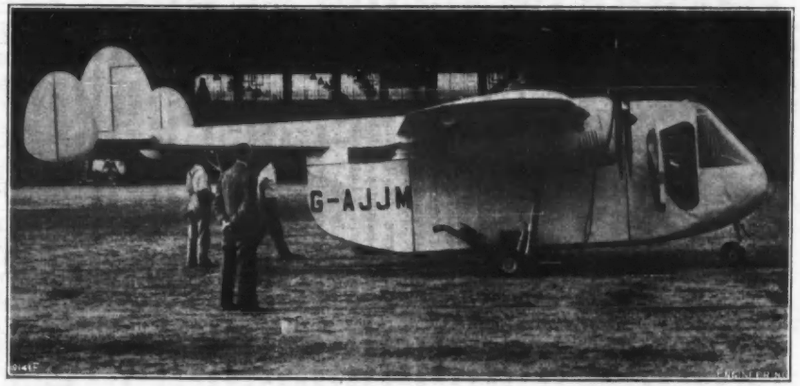


FIG. 6. "M68" DETACHABLE-HOLD FREIGHTER; MESSRS. MILES AIRCRAFT LIMITED.

FIG. 7. "M68" FREIGHTER WITH HOLD REMOVED; MESSRS. MILES AIRCRAFT LIMITED.

FIG. 8 "MERGANSER" FEEDER-LINE AIRCRAFT; MESSRS. PERCIVAL AIRCRAFT LIMITED.

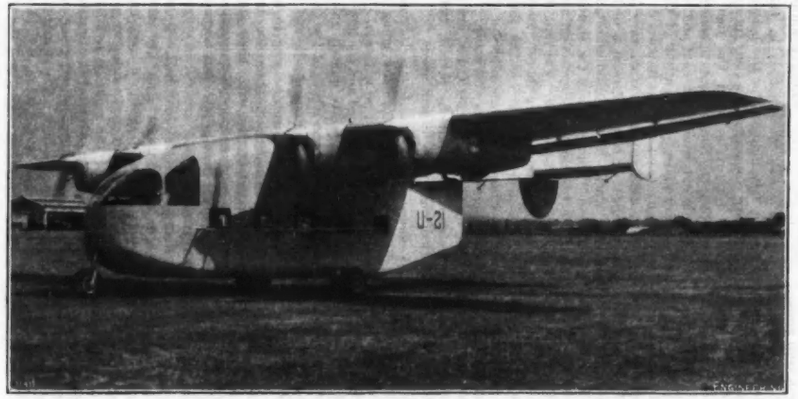


FIG. 9. "MERCHANTMAN" AIR FREIGHTER; MESSRS. MILES AIRCRAFT LIMITED.

INFRA-RED HEATING FOR DRYING SHEET RUBBER.

DURING the period when rubber supplies were very scarce, some of the raw material which the Dunlop Rubber Company had to utilise required washing after being processed into sheet form. The subsequent drying of this material was a difficult problem, since when air drying was employed it took from one to three weeks and occupied valuable factory space. In order to expedite the operation, the Dunlop Company carried out extensive investigations, in conjunction with Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, into the possibilities of infra-red heating. Initially a pilot plant was installed to enable tests to be carried out on a production scale, and, when this proved that the evaporation of moisture from washed sheet rubber by infra-red radiation eliminated a serious production bottle-neck, a plant incorporating 624 infra-red lamps and reflectors was erected.

This main plant consists of a heating section, which is 40 ft. long, the total length of the oven, with the conveyor-loading and unloading positions, being 75 ft. The total lamp load is about 190 kW. This is somewhat higher than would be expected from 624 250-watt lamps, but is due to the fact that the lamps are run at a higher voltage than the normal figure of 115 volts. The plant is constructed in tiers, the wet rubber being fed initially under the top tier of lamps, so that one side of the sheet is irradiated during the first 40-ft. pass. The sheet is then automatically doubled back on the conveyor through the centre 40 ft. of the oven, thus exposing the other side of the sheet to the radiation. The final 40-ft. pass is not provided with lamps, but constitutes a residual heating section. The rubber travels at a speed of 4·5 ft. per minute, so that the time taken to complete the three passes is about 27 minutes, compared with three weeks previously required. The rubber is about $\frac{1}{4}$ in. thick and is fed in in two continuous sheets about 20 in. wide. The initial moisture content is from 10 per cent. to 12 per cent. of the dry weight and the final moisture content is from 1·2 per cent. to 4 per cent. On test, the temperature of the rubber at the end of the first pass was 107 deg. F.; at the entrance to the second pass it was 57 deg. F., and at the end of that pass 116 deg. F. The electricity consumption was 2,474 kWh a day for a rubber output of 10,246 lb., the consumption per pound of rubber therefore being 0·24 kWh. In another test, the temperature of the rubber leaving the first pass was 94 deg. F., and the moisture content of 11·2 per cent. was reduced to 3·6 per cent.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 163.

The Index to Vol. 163 of ENGINEERING (January-June, 1947) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, SEPTEMBER 26, 1947.

VOL. 164. No. 4261.

TECHNOLOGICAL QUALIFICATIONS.

SINCE the publication of the Barlow Report suggestions have been made several times, in these columns and elsewhere, that greater use ought to be made of technical colleges to increase the scientific manpower of the country. In so far as their potential contribution concerns the training of students for responsible original work in the State-sponsored scientific services and in industry, attention must evidently be directed, in the first place, to those colleges which already provide courses in technology of a standard claimed to be comparable with that of university-degree courses. From the survey of technical education recently made by the Percy Committee, it appears that some 27 institutions, ten of which are in the London area, may be regarded as major colleges of technology, either for the quality of the advanced courses of study followed in certain subjects, such that students may take external degrees, or because some of their technical departments are recognised by local universities as qualifying for internal degrees. Recent proposals for the organisation of higher ranges of study on a regional basis throughout the whole country are manifestly aimed at extending the principle of advanced technological education, and thereby increasing the output of men and women adequately trained to meet the urgent national need. The suggested organisation is to include an advisory council and an academic board in each of the ten regions into which England and Wales is to be divided, the apex of the structure being a National Council of Technology for the whole country.

These recommendations, emanating mainly from the Percy Committee and subsequently accepted in principle by the Ministry of Education, have also received generally favourable consideration, among a number of related matters, by the Parliamentary and Scientific Committee, who have recently submitted to the Lord President of the Council a detailed report of their views on the manner in which colleges of technology should contribute to the technical manpower problem. Under the chairmanship of Mr. M. P. Price, M.P., this Committee comprises representatives of 70 scientific organisations and some 200 Members of Parliament and Peers of all political parties. Last year they issued a similar report, entitled "Universities and the Increase of Scientific Manpower," and the basis of the present report may be said to reside in the doctrine that, owing to the character of advanced educational facilities in this country, no clear line of demarcation can be drawn between the functions of the universities and the major colleges of technology. This is not to imply that there is not ample scope for both, but rather that both can contribute jointly to the national need, not as competing, but as complementary institutions. The Committee, however, have been deeply impressed by a recent American statement to the effect that the United States can no longer count on Europe as a source of fundamental knowledge, and that, in consequence, America must itself pay increased attention to pure research. The Committee consider that Britain is one of the sources of original scientific thought which other countries have applied to their own commercial advantage; and that henceforward, Britain's material prosperity will be best advanced by increased attention to applied science, turned to profitable ends by trained technologists.

Although the Committee are careful to say that any expansion of technology must not be made at the expense of needed developments in the arts, humanities, sociology and fundamental science, and the proportion of brains attracted into technological study must not be unduly large, it is plain that industrial application is considered to be a more paying proposition, and therefore more desirable, than the pursuit of scientific knowledge for its own sake. To a country in the present situation of ours, especially in relation to the United States of America, this is so plausible a view that the emphasis placed on it by the committee seems hardly necessary. Throughout the whole war period the outlook of academic science was turned to immediate tasks, with results that are as well known as they were triumphantly successful. Since however, nobody can be more intimately aware of these facts than the President of the British Association, Sir Henry Dale's wise and significant words on this subject in the course of his presidential address at Dundee deserve the most serious attention. His fear was not that technologists would be lacking, but that scientists would find it difficult to relinquish the spendthrift habit of research, the policy of trading for quick returns, to the detriment of long-range fundamental work.

If the insistence of the Parliamentary and Scientific Committee on the predominant need for technologists is not upheld by the leaders of scientific thought, it will not be surprising if the methods by which the Committee propose to supply that need are also open to criticism on a wider scale. Their argument, briefly, seems to be that since the technological colleges can train a large number of men, and since what is wanted is a large number of qualified men, all that is necessary is to award the trained man a qualification. Since, moreover, the status of the universities is associated in the mind of the public with their power to confer degrees, which are generally accepted as a standard of attainment, the technological qualification should be a degree. This conclusion is associated with a recommendation, which may fall on some ears uncommonly like a threat, that the proposed National Council of Technology should suggest broad lines for the national development and co-ordination of higher technological studies in universities; and, further, will have to consider whether a new organisation for granting degrees is needed.

There is a specious quality about this line of reasoning which may well have been the chief of the points on which the Committee's Report was, as its introduction states, subject to dissent by representatives of the Institute of Physics. For one thing, physics is the science *par excellence*, from which all branches of applied science are derived; and it is generally true to assert that the more advanced any technology becomes, the more nearly does it revert to physics. The mere technology, concerned with the practical aspects of a craft, may therefore

be contrasted with the pure science which treats of the fundamental nature and behaviour of the materials and phenomena employed in the craft. The technology teaches how to use them: the science how to use them better. Recognition of this distinction, and of its importance in the long run to the individual under training, the industry he will serve, and the intellectual credit of the nation, is at the root of what may seem an intransigent attitude of the universities as regards their jealously guarded privilege of conferring degrees. It accounts for the thoroughly scientific foundation of the education characterising the university schools of technology and for the discrimination displayed in awarding degrees to students in technological institutes. It explains the regard paid to the manner as well as to the matter of the teaching, which, in turn, reacts on the attitude of mind of the student, his capacity for clear thinking and expression, and his ability to view and review comprehensively. In short, it marks the difference between education and training.

The foregoing attempt to formulate a general principle held by the universities does not for a moment dispute that some training in some technological institutes may not at some time be superior to that in some universities. Both have their vintage years, as regards staff and students. Nor does it imply that the technological institutions are not serving a great, and a potentially greater, purpose. It is intended as criticism of the Parliamentary and Scientific Committee for emphasising the degree more than the justification for the degree. Lacking the quality that would make it not only equivalent in theory, but also manifestly equivalent in fact, the degree, extravagantly awarded, would do little more than lower the value of a hardly-earned qualification, which owes the respect in which it is held not only to the education on which it sets a seal, but quite as much to the proven accomplishments of those who have gained it in the past.

If, therefore, the Committee are correct in contending that the dearth of qualified scientists and technologists can be quickly enough supplied only by attracting highly able students to technological institutions with the prospect of a bachelor degree, the first task would appear to be to make those institutions completely equivalent to the universities. While not seeing this as the primary and essential step in the direction of the widespread award of nationally and internationally recognised degrees for technology, the Committee realise that changes would need to be made in some existing technological colleges in order to raise the courses to university standard. Here again, however, their main concern is restricted to salary scales appropriate to highly qualified staffs, to which is appended a commendable recommendation that lecturers should be able to enter industry for refresher periods. The matter evidently goes much deeper than this. For years there have been several fine colleges turning out high-grade technicians in various parts of the country, which—as the Committee are fully aware—have not been accorded university status. In many other cases, evening classes at technical colleges are given by men who lecture at a local university during the day.

The reasons why such leading colleges are dependent upon universities for external degrees are rarely made public, but it is not unreasonable to suggest that the combination of faculties of arts along with those of science, the pursuit of the intellectual life on broad lines, the balance between humanities and sciences, and the potentially benign influences of these factors on the undergraduate mind, are regarded by the universities as of comparable importance with technical training. Hence it is not easy to envisage any worthwhile alternative to an increase in the number of universities in order to supply the increased number of degrees that the Parliamentary and Scientific Committee are anxious to produce; and that is a very long-term project. For the present, and the immediate future, the technological colleges have a very important part to play in the national economy. There is room for them, for their students, and their qualifications, as well as for the universities and all that they have to offer.

INTELLECTUAL FREEDOM.

In the Middle Ages, when intellectual authority was exercised by an ecclesiastical organisation centred in Rome, men were not free to study the facts of nature and to proclaim any opinions to which their research had led them. At that period, and in the Dark Ages which preceded it, experimental science was to a major extent concerned with the subject of alchemy. Work was mainly directed to the discovery of the Philosopher's Stone, which, it was believed, would turn base metals into gold. There is no reason to suppose that all workers in this field were merely engaged in an effort to find an easy road to wealth; many appear to have been honestly endeavouring to attain knowledge of natural phenomena. This early striving in the dark was not wasted; it blazed a trail which has led to the modern edifices of chemistry and physics. The service which alchemy rendered to mankind was well expressed by Lord Bacon, who wrote "Alchemy may be compared to the man who told his sons that he had left them gold buried somewhere in his vineyard; where they by digging found no gold, but by turning up the mould about the roots of the vines, procured a plentiful vintage."

A belief in the transmutation of metals lingered until the Eighteenth Century, but it probably received its death blow by the publication of *The Sceptical Chymist*, by Robert Boyle, in 1661. This book pointed out that the aim of chemistry should not be to produce gold, but to "find out nature, to see into what principles things might be resolved." This publication marked the birth of modern chemistry. In due course, the atomic theory of matter was worked out. Lavoisier clearly enunciated that matter was indestructible and Dalton established the atomic theory on a quantitative basis. This specific, and what may be described as mechanical, explanation of the constitution of matter, was well suited to the logical minds of the Eighteenth and early Nineteenth Centuries, but towards the end of the latter a theory of a more transcendental nature began to emerge. A new technique had become available, and, in 1879, Crookes suggested that cathode rays were composed of small particles. This was confirmed by the work of Thomson, which led up to the work of Rutherford and the developments of to-day, which have demonstrated that matter is not indestructible and that Dalton's statement that "no man can split an atom" was not correct.

If the departed spirits of the alchemists are able to keep in touch with earthly proceedings, they are likely to find considerable satisfaction in the fact that the developments of the Twentieth Century have shown that their contentions were fundamentally correct, that the Philosopher's Stone, although not in the form in which they envisaged it, is a reality and that the possibility of the transmutation of metals was no idle dream. They failed in their work because their information and their methods were too crude; not because they were chasing a mirage. These disembodied spirits may observe a further aspect of interest, possibly of amusement, in the proceedings of the Twentieth Century. In the Middle Ages, the long arm of a paramount Church controlled, and to a large extent forbade, scientific speculation and experiment. The astronomers of that time either concealed the results of their researches or published them in a garbled form which was calculated not to run counter to ruling ideas. The modern scientist is not subjected to the authority of any ecclesiastical body but, in perhaps the most important field of modern science, he is in the toils of an authority equally potent. His activities, and the publication of any results to which he may come, are directly controlled by the Government of the day. Under the Atomic Energy Act, it is illegal for a physicist working in the field of atomic energy "to publish his results or even to discuss them with a colleague."

The reasons for this procedure are well understood, but that does not lessen the dissatisfaction that may well be found in the fact that, in the intellectual sphere, the practice of the Twentieth Century is approximating to that of the Twelfth. This is little to the credit of an age which prides itself not merely on its material advance, but also on its rejection of all intellectual shackles. In international affairs it is the custom to employ roundabout terms in referring to the activities of foreign nations, but as everyone now understands that the purpose of the Atomic Energy Act is to prevent detailed information about the American atomic-bomb plants coming to the knowledge of Russia, it is just as well to say so. The precautions which are being observed can, however, be only of temporary efficacy. As Professor Peierls pointed out in the interesting and acute analysis of the position contained in the address entitled "The Effect of Atomic Energy on Scientific and Technical Publications," which he delivered before the 22nd annual conference of Aslib, on September 19, it is impossible to prevent other countries themselves working out methods of constructing atomic bombs. The fundamentals of the matter are common knowledge among the scientists who are able to understand them, and the setting up of manufacturing plants is largely a matter of applied research, a sufficiently large staff of instructed workers, and material resources.

Professor Peierls, whose address we commence to reprint, in abridged form, on page 305, pointed out that the present policy of secrecy may possibly postpone detail knowledge of large-scale atomic plants from becoming available until such times as international control of their construction and use has been developed, but it cannot be said that the prospects for this happy situation are promising; these, however, are matters of high politics, or perhaps one should rather say, of low politics, with which Professor Peierls was not concerned and which need not be discussed here. His examination of the situation under which individual workers, say, in university laboratories, find themselves under the dual impact of the Official Secrets Act and the Atomic Energy Act is of direct interest and importance. It appears that machinery has been set up by which reports dealing with some aspect of atomic energy which the authors may desire to publish are referred to a team of "responsible reviewers" which determines whether or not they should be released. In accordance with standard Government practice, however, these responsible reviewers, who presumably know more about the matter than anyone else, cannot decide that a report may be published; they can only recommend that it may. The final decision is taken by "officials of the appropriate Ministry, who will act on the authority of the Minister." This procedure may work harmlessly in the majority of cases, but it is yet another example of the extension of Civil Service control and embodies the possibility that some individual Minister may suppress vital information for reasons far removed from the interests of scientific advance.

The opening paragraphs of Professor Peierls's address are concerned with the international nature of science. It is pointed out that "a thought expressed by someone, say, in Cambridge, may at once lead to comments by a scientist in Copenhagen which show the right use for a machine available in Princeton." With the policy now adopted, this fruitful interchange of knowledge and opinion will be made impossible over a large branch of physics, and scientific advance will not merely be made more difficult: it will be retarded. It may be that these restrictions are unavoidable in the pseudo-civilised conditions in which mankind has landed himself, but that is no reason why further hampering controls should be devised. The monetary sum concerned in the recent decision to prohibit the import of scientific books, except under licence, must be trivial in relation to national expenditure, but the effect of the measure on scientific work may be serious. The negotiations, form-filling and delay which an individual worker may have to face before he is allowed to purchase a foreign publication, which may be essential if he is to keep properly in touch with developments in his particular field, may be such that he will abandon the attempt to obtain it. Even assuming that the licensing authority desires to assist in every way, decisions must be made by some official who cannot possibly judge the relative importance of different applications for purchase, or determine to what extent some valuable research may be assisted or retarded by his decision.

NOTES.

INSTITUTION OF NAVAL ARCHITECTS.

THE autumn meeting of the Institution of Naval Architects was divided this year between two centres, Portsmouth and Southampton, two days being spent in each. The meeting opened on Tuesday, September 23, in the Municipal College, Portsmouth, when the members, headed by the President (Admiral of the Fleet Lord Chatfield—himself a native of the city) were welcomed by the Lord Mayor of Portsmouth (Councillor R. J. Winnicott), the Commander-in-Chief (Admiral Lord Fraser) and the Mayor of Gosport (Alderman A. R. Nobes). In the course of his introductory remarks, Lord Chatfield, who occupied the chair, disclosed that, on the termination of his period of office in 1948, he would be succeeded as President by Admiral of the Fleet Lord Cunningham. He mentioned also that the revision of the by-laws (which he had stated, at the Spring Meeting, to be in progress), had been completed, and that the revised by-laws would be submitted to the members for consideration at a special meeting to be held in October. The Lord Mayor, in his address of welcome, referred to the fact that this was the first visit of the Institution to Portsmouth, although so many of the members had intimate associations with the Royal Dockyard. Lord Chatfield then called on Vice-Admiral L. V. Morgan, C.B., M.V.O., Admiral Superintendent of the Dockyard, to present the first of the six papers in the programme, which was "An Historical Review of Portsmouth Dockyard in Relation to Our Naval Policy." This he did in a short but skilful summary, in which he made the significant point that the Royal Navy (and with it the Royal Dockyard) had waxed and waned according to the foreign policy of the time, but, when it was allowed to wane, prolonged peace had not necessarily ensued; British weakness at sea, in fact, had been more than once a contributory factor to another war. The second paper, by Mr. L. G. Bell, R.C.N.C., described "Some Model Experiments on the Effect of Blade Area on Propeller Cavitation," carried out in the cavitation tunnel at the Admiralty Experiment Works, Haslar. The presentation of this paper, also, was notable for the ability with which the author condensed the essence of a somewhat complex subject into a summary occupying hardly more than a quarter of an hour. The meeting then adjourned for luncheon, after which parties visited the Admiralty Experiment Works, the Bridgmary housing estate at Gosport, the Dockyard and H.M.S. Victory, and the "D-Day" operational wall map used in the invasion of Normandy and now preserved at Southwick House (H.M.S. Dryad). The meeting on Wednesday, September 24, also held in Portsmouth, opened with the announcement of the election of new members, the accessions including, with transferences, 30 members, 44 associate-members, 23 associates and 40 students. A paper by Mr. W. C. S. Wigley, M.A., and Professor J. K. Lunde, M.Sc., on "Calculated and Observed Wave Resistances for a Series of Forms of Fuller Mid-Section" was then presented and discussed. In the afternoon, visits were paid to the Cunard-White Star liner Queen Elizabeth at Southampton; and to the School of Navigation at Warsash. The remaining two days of the meeting were spent in and near Southampton, where it was to conclude to-day (Friday) with a cruise in the Solent. The three papers to be presented at the technical sessions at Southampton on Thursday—too late for the inclusion of a report in this week's issue—were "The Port of Southampton," by Mr. O. H. Lewis; "Permanent Moorings," by Mr. T. Thorpe, R.C.N.C., and Mr. K. P. Farrell, B.Sc., R.C.N.C.; and "Resistance of Barges in Deep and Shallow Water," by Mr. J. F. Allan, B.Sc., and Mr. W. P. Walker.

NATIONAL GAS-TURBINE ESTABLISHMENT.

Contrary to general belief, this country has a large leeway to make up in the application of gas turbines to industry. The work of the National Gas Turbine Establishment, therefore, has an important bearing on our national economy; and some interesting information was given by the Director, Dr. H. Roxbee Cox, during a recent Press conference held at the Whetstone Establishment. Dr. Roxbee Cox pointed out that the National Gas Turbine Establishment existed for the purpose of increasing the store of knowledge of gas turbines in all their applications, and the work of the Establishment included research into basic problems of air flow, combustion, behaviour of materials at high temperatures, stresses in components under working conditions, which included the effects of vibration, and methods of manufacture. The results of these fundamental researches were being applied continually to improvements in the design of compressors, turbines and other components, and the knowledge gained was handed on to industry through the medium of reports and by direct contacts. Dr. Roxbee Cox then said that it was not their policy to produce complete engines; the manufacturing department was occupied in making experimental components of advanced design, either for test purposes or for ultimate embodiment into engines, while a large part of their facilities was engaged on the manufacture of testing equipment. The Establishment, however, undertook the technical assessment of new designs and tested compressors, turbines and complete engines submitted by outside firms. Dr. Roxbee Cox then gave a brief résumé of the origin and development of the Establishment. It came into being officially, he said, on July 1, 1946, but this was the culmination of developments which had arisen from small beginnings. Pioneer work had been done by Air Commodore Whittle and by the Royal Aircraft Establishment, and Air Commodore Whittle's company, Power Jets, Limited, was formed in 1936. Power Jets, Limited, received Government backing in 1937, and in 1942 the Royal Aircraft Establishment's team was provided with a separate laboratory at Pyestock. The next step, Dr. Roxbee Cox continued, was the amalgamation of Power Jets, Limited, and Pyestock into the Government-owned company, Power Jets (Research and Development), Limited, which took place in May, 1944. On the change to the present status, the National Gas Turbine Establishment took over all the functions of the company excepting the administration of the gas-turbine patents, which continued to be handled by Power Jets (Research and Development), Limited, from their London office. With regard to the future, Dr. Roxbee Cox said that it was the Government's policy to bring the various branches of the Establishment together at Pyestock as soon as practicable. Plans were under way for additions to the test equipment, and these included plant for the testing of compressors up to 14,000 h.p. and test beds for marine power plants. He hoped that it would be possible, eventually, to test aircraft engines of high power under conditions equivalent to those found at altitudes of 80,000 ft.

INSTITUTE OF METALS; GLASGOW MEETING.

The thirty-ninth annual autumn meeting of the Institute of Metals opened in Glasgow on the evening of Tuesday, September 23, and will be brought to a conclusion to-day, Friday, September 26. The proceedings on the first day commenced at 8 p.m., at the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, where a welcome was extended to the members by Sir James Weir French, D.Sc., Honorary President of the Reception Committee. Brief speeches of welcome were also delivered by Councillor Andrew Hood, J.P., Deputy Lord Provost of Glasgow, who represented Sir Hector McNeill, the Lord Provost; Professor R. Hay, who represented Sir Hector Hetherington, the Principal of the University of Glasgow; and Mr. W. H. Marr, President of the Glasgow Chamber of Commerce. In the course of his speech, Professor Hay recalled that the Institute's first autumn meeting in Glasgow had taken place in 1910. Since that date, a Degree in Metallurgy had been established in Glasgow although it was known as a Degree in Applied Chemistry. Mr. Marr, who also spoke, said that while Glasgow and the West of Scotland constituted essentially an area of heavy industries, non-ferrous metals were used to a considerable extent in the local shipbuilding industry and other works. The Institute stood for research, and, at present, the maintenance of quality of products was an important factor in the economy of the country. The President of the Institute, Colonel P. G. J. Gueterbock, C.B., D.S.O., M.A., thanked the speakers for their cordial welcome, after which he introduced Professor G. Wesley Austin, O.B.E., M.A., M.Sc., and invited him to deliver the 25th Autumn Lecture. In doing so, he stated that Professor Austin, who occupied the Chair of Metallurgy at the University of Cambridge and was a vice-president of the Institute, was well known to Glasgow audiences as he had been Superintendent Scientist at the Royal Naval Torpedo Factory at Greenock for many years. Professor Austin, who had chosen as his subject "The Metallurgical Resources of Scotland," said that although lead, copper, nickel and other metals were to be found in small quantities, Scotland, on the whole, was poor in ores, with the exception of her celebrated black-band ironstone. On the other hand, Scotland possessed enormous resources in coal of various qualities and abundant supplies of high-grade dolomite, fireclay and other refractories were available. Scottish water-power resources were also considerable. At the conclusion of the lecture, a vote of thanks to Professor Austin was proposed by Mr. A. Craig Macdonald, vice-chairman of the Scottish local section of the Institute, and seconded by Mr. A. B. Graham, chairman of the section. The President then adjourned the meeting until the following morning.

L.N.E.R. ELECTRIFICATION TO SHENFIELD.

A brief interim report on the progress which has been made with the electrification of the Liverpool Street-Fenchurch Street-Shenfield line has been prepared by the London and North Eastern Railway Company. It will be recalled that the scheme is intimately connected with the Epping and Ongar extension to the London Passenger Transport Board's underground Central Line, which is now open as far north-east as Leytonstone. Most of the heavy engineering work on the L.N.E.R. scheme is now completed. It has included the construction of heavy retaining walls, new platforms, the widening of bridges, and the construction of a fly-over viaduct at Ilford to carry the suburban line over the main line. Some reconstruction of bridges remains to be done, and also at several places under bridges, the track is to be lowered to provide extra height for overhead electrical equipment. The introduction of the Ilford fly-over viaduct has necessitated alterations to track routes between that point and Liverpool Street, particularly at Stratford, Bow Junction and Bethnal Green, and the opportunity has been taken of simplifying the layout at junctions to permit smoother and faster running. As a result of these track alterations, the stations at Stratford, Maryland, Forest Gate, and Manor Park have had to be reconstructed. Work on the platform buildings has been delayed owing to the shortage of materials, but it is hoped to complete those at Stratford and Maryland by October 5, when the Ilford viaduct will be brought into use. Interchange platforms between the L.N.E.R. local lines and the L.P.T.B. Central Line have been provided at Stratford. After October 5, the most important work awaiting completion will be the re-arrangement of the track at Liverpool Street. This will be started at 11 p.m. on October 28, and will take nearly a year, with full week-end working. It will require continuous co-operation between the engineering and operating staffs to minimise interference with traffic working. During recent weeks, 152 foundations for overhead electrical equipment have been laid, and 175 masts and 134 bridge members erected. About 35 per cent. of the overhead structures have now been provided. Much of the work on the scheme, particularly in connection with signalling, is temporary, to conform with the alterations to the tracks, but will remain in use until the final signalling system is introduced. It is understood that 276 coaches, forming 32 multiple-unit electric trains, are to be built. The manufacture of electrical equipment is well in hand and deliveries are expected to start next month. The L.N.E.R. is hampered by uncertainty regarding labour and materials, so that it is impossible to forecast a date for completion of the work.

THE ROYAL OBSERVATORY.

THE latest annual report of the Astronomer Royal covers the period of 12 months up to the end of last April. It deals mainly with the astronomical work conducted at the Greenwich Observatory, the time service and magnetic observations maintained at Abinger, and, in less detail, with the establishment at Bradford-on-Avon where the repair, adjustment and rating of chronometers and watches for use in the Royal Navy are carried out. The purchase of Hurstmonceaux Castle, together with some 370 acres of land, has been completed during the year, but little else than planning has been achieved as regards the transfer of the Royal Observatory to its new site, since the removal of staff as well as equipment is governed by the rate at which building can be carried out. It is hoped, however, to erect, during the present financial year, a solar building at Hurstmonceaux to house the photo-heliograph, two spectroheliosccopes and spectrographic instruments now at Greenwich, and also to transfer the staffs of the solar and several other departments. Two large refractors, now out of use and deteriorating because their domes suffered bomb damage, are to be dismounted and stored at the Castle until new domes can be built to house them there. The decision has also been made to erect the new Isaac Newton telescope in the gounds at Hurstmonceaux. It will be recalled that, to commemorate the Newton Tercentenary in 1946, public funds were provided for the construction of a reflecting telescope of 100 in. aperture, which considerably exceeds in light-gathering power any telescope at present in this country. Under the administrative control of the Astronomer Royal, presiding over a Board of Management, the telescope will be available to qualified astronomers from all British observatories, and will greatly extend the observational programmes hitherto possible.

Another important instrument to be installed at Hurstmonceaux is a photographic zenith tube, intended to afford a substantial and needed increase in the accuracy of time and longitude determinations. The construction of this telescope, by Messrs. Sir Howard Grubb, Parsons and Company, has been in progress throughout the year. Recent attention has been directed particularly to the mechanisms for constraining and driving the carriage, for which purpose, tests have been made, in collaboration with the Observatory staff, on a small-scale model to reveal certain features of mechanical design. An important modification of the originally proposed photographic timing system has been made to bring the optical axis vertical, so that the co-ordinates on the timing plate may include the declination, which is of critical importance, while by the same change the constraint and motion of the timing-plate carriage are simplified. Other sources of mechanical error have been avoided by the introduction of an auxiliary carriage for the stellar-plate, mounted on an optically flat surface. Research has been made also to estimate and minimise inaccuracy arising from distortion of the projector used in the photographic timing system, and to decide upon the most suitable type of photographic plate. Improvements have also been made in the stability and mode of adjustment of the basin which is to contain the pool of reflecting mercury, in which connection the departure from true level of a shallow pool of mercury has been investigated to ensure that the requisite accuracy—of the order of 0·01 second—will be achieved. For measuring the stellar plates to be obtained when the zenith tube is in use, comparisons are being made between a photometric device, developed by Messrs. Ferranti Limited, and visual methods, to discover which promises the greatest precision and convenience.

Some of the experiments directed primarily to developing the photographic zenith tube are also of value for a new horizontal transit instrument, now in course of construction, which embodies a mercury basin and needs carefully selected photographic plates. For the practical side of the transit, the glass optical components of the variable-deviation system, and a special set of polished stainless-steel blocks for the timing system, have been made, while an electrical drive, of the direct-current, motor-generator type, for operating the variable-deviation system has been developed experimentally. On the observational side, micrometric examination of stellar trails photographed with the existing Cookson floating zenith telescope is yielding quantitative information about the erratics to which the position of bisection of a stellar image is subject as the result of atmospheric irregularities. Another instrument, now at Greenwich, is being completely overhauled in preparation for the observation of time and latitude stars to be used with the photographic zenith tube. This is the reversible transit circle, in which some obscure pivot irregularities have called for elaborate investigation. Among a number of peculiar features, the pivot errors appear to vary in magnitude according to the direction in which the telescope is being turned, and it has not yet been established whether the inaccuracy observed is due wholly to pivot errors or partly to variations in the optical system. These difficulties are perhaps responsible for a proposal to construct a transit circle in which the moving parts are reduced to a minimum, and in which an accurate control of instrumental errors will be possible. In the design, to which some preliminary consideration has been given, the moving portion consists of a mirror supported by trunnions to the east and west. Two horizontal viewing telescopes in the meridian respectively to north and south of the mirror, are to be used for star observations and also as collimators. A general discussion of the principles of this instrument is in course of publication by the Royal Astronomical Society.

From the viewpoint of the engineer, many of the most interesting activities of the Observatory are associated with the time service, centred at Abinger, in connection with which a number of 98-ft. Adastra masts have been erected recently on Wotton Common for the reception of foreign time signals. At the station itself, the 12 quartz clocks and their associated equipment, which it was decided some years ago should replace the time-keeping standards then in use, have been installed completely by the Radio Branch of H.M. Post Office, and are now operated entirely by battery supply with a valuable reduction in the number of failures and stoppages due to interruptions of the mains electricity supply. For observations and comparisons of rate, the 12 clocks are operated in four groups of three, and the Abinger clocks during the year have improved generally as regards stability of rate, indicating that the quartz crystals are beginning to settle down after exhibiting, during the initial stages of operation, the rapid and unpredictable drift of frequency that is characteristic of this type of oscillator. Five of the 12 clocks have performed more satisfactorily than the others and have been used therefore to operate the phonic motors for the transmission of time signals. Normally, one particular clock has controlled the emission of the rhythmic time signals, and has served as a frequency standard for some experimental transmission at a frequency of 2 Mc/s. The power radiated in the latter has been markedly increased during the year by the incorporation in the circuit of a newly designed aerial-matching unit, a 300-watt transmitter being adapted for the purpose. Great care has been taken to secure a high phase stability in the design of the 100 kc/s to 2 Mc/s converter; with good results, since reception is reported to be entirely satisfactory at the Post Office Research Laboratories at Dollis Hill, and also at the B.B.C. Receiving Station. Equipment to permit semi-automatic operation of the transmitter has been designed, constructed and tested, and is now in course of installation.

An important conclusion reached regarding the conversion of the high-frequency quartz oscillations to lower frequency indications, is that the beat counters hitherto in use at Abinger for this purpose are not satisfactory, especially when the two clocks of a pair undergoing comparison have a large relative rate. Accordingly, an improved pattern of beat counter has been designed and will be fitted first for tests in a quartz-clock installation at Greenwich. Until supplies of the counter become available for Abinger, the clocks at that station are being checked by a simple frequency comparator used in conjunction with a decimal counter chromometer. By this method, frequencies may be compared to an accuracy of about 1 part in 10″, but only instantaneous relative values can be determined and these may differ slightly from the mean daily rates. Among several recent modifications to the decimal counter chromometer installation, provision has been made for the selection of one of four standard count frequencies. A device has been fitted which enables the counter to start and stop on consecutive pulses in the same channel, and seconds impulse dials for checking comparison times have been provided. The installation of equipment in the new time-service control room is now nearing completion. Efficient maintenance and adjustment are of great importance on account of the complex instruments now used for precision time-keeping, and in the practical design of the new equipment much attention has been directed to features which will facilitate the testing of components and the rapid replacement of any found defective. As far as possible, all essential parts of the system will be duplicated to permit immediate switch-over from a faulty unit to a reserve, the discovery and rectification of the defect being left for the specialist staff to deal with at leisure.

The value of radio transmissions of precise time standard signals, as an aid to longitude determination, is illustrated by a special series of observations, undertaken between August and December of 1946, at the request of the Director of the Australian Commonwealth Observatory, to derive a more precise value for the longitude of the observatory at Mount Stromlo. This involved the erection at Abinger of a rhombic aerial to receive special radio time signals transmitted from Belconnen, near Canberra. Signals in the reverse direction were sent from Rugby to Stromlo, where reception, at first unsatisfactory, was adequately improved by changing from a directional to a non-directional aerial at Rugby. The principal outcome of the experiments was to show that no correction was necessary to the value already adopted for the longitude of Abinger, but that the previously accepted longitude of Mount Stromlo placed that observatory 0′ 103″ too far to the east.

Another interesting transmission took place on April 18, 1947, when a special time signal, consisting of ten minutes of mean-time seconds dots, was sent out from the Observatory and radiated by the B.B.C. for the purpose of timing the Heligoland demolition seismic experiments. As regards the normal programme at Abinger of time-signal transmission and reception, some increase in the number received has occurred recently, and they now include transmissions from France, America, Moscow, and Tashkent in Russia, as well as long- and short-wave British time signals. Whenever reception is possible, daily comparison is made between the Abinger clocks and the seconds pulses superposed on the standard frequency emissions from the Bureau of Standards at Washington. Between February 8 and April 13 this year, damage caused by icing of the aerial at the Rugby radio station prevented transmission from there of the daily signals at 10 a.m. and 6 p.m. During this period the signals were sent out from the station at Criggion, but although by this means continuity was assured with adequate accuracy for navigation, some loss of precision was caused by the slow and unsteady build-up of the signals, combined with variations in land-line lag and signal strength at the receiver.

The severe weather of the past winter has led to a number of exceptional values being recorded by those departments of the Observatory which are concerned with meteorology and geophysics. The mean temperature, for example, was only 48·4 deg. F., which is 1·3 deg. F. lower than the average over the hundred years from 1841 to 1940. Temperatures exceeding 80 deg. F. were recorded at Greenwich on only 9 days, while the lowest temperature, 9 deg. F., which occurred on February 24, 1947, was the lowest recorded since February 8, 1895. Temperatures of 32 deg. F. or below were recorded on 75 days, 26 of which were in February; and February's mean temperature was 10·5 deg. F. below the average for the past 100 years. The total period, 1,239 hours, of bright sunshine was only 27·7 per cent. of that theoretically possible, and there were 85 entirely sunless days, of which 69 were in the five months November to March. The total rainfall, 30·63 in., is 6·3 in. more than the hundred years average. The wettest month was March,

with 5·216 in. Throughout 130 years, since scientific recording started, this figure has never been approached for the month of March, and it is more than an inch higher than the previous high record of March, 1916.

Less spectacular values occurred in the other meteorological records, which, as usual, included the temperature, pressure, humidity, and movement of the atmosphere. An automatic type of Owen's filter is used for recording atmospheric pollution by solid particles, and this year an additional instrument for measuring gaseous pollution, more particularly by sulphur dioxide, at Greenwich is being maintained and operated by the Atmospheric Pollution Section of the Department of Scientific and Industrial Research. The regular observations of the elements of terrestrial magnetism, carried out at Abinger, likewise, exhibit no remarkable features, although the accompanying table of mean values reveals an interesting contrast between the variation of inclination and horizontal intensity, and the regular trends of declination and vertical intensity, during the past four years.

Year.	Declination (West).	Horizontal Intensity.	Vertical Intensity.	Inclination.
1943	10° 16·2′	0·18556	0·43172	66° 44·5′
1944	10° 7·8′	0·18566	0·43189	66° 44·3′
1945	9° 59·5′	0·18573	0·43207	66° 44·3′
1946	9° 51·1′	0·18569	0·43235	66° 45·4′

Mean hourly values of declination are regularly published by the Observatory as part of its information service, and weekly reports of the magnetic character of each day are also communicated to a number of geophysical research centres to assist their experimental work. During the past year there have been 18 magnetic disturbances reaching the dimensions of a "storm," of which four can be characterised as a "great storm," causing a range exceeding 1 deg. in declination or 300 γ in horizontal intensity. The most severe magnetic disturbance occurred on July 26-27, 1946, when ranges of 925 γ in horizontal intensity, and 620 γ in vertical intensity, were recorded.

It is plausible to suppose that some connection exists—incompletely understood since the report does not draw attention to it—between magnetic storms and sunspots, which are regularly observed by the photoheliograph at Greenwich and studied in great detail. It is significant, for example, that a giant group of sunspots reached its central meridian position on July 26, 1946. Other phenomenal sunspots were observed in March and April of 1947, the last, and largest, having an area of approximately 5,400 millionths of the sun's hemisphere. Thus, within fourteen months, the previous record sunspot of February, 1946, with an area of 4,900 millionths, has been surpassed, while the spots of March, 1947, and July, 1946, are probably the third and fourth largest ever to be recorded. The Astronomer Royal considers that the appearance of these giant spots, together with an increase in the mean monthly sunspot number to 110, as compared with only 48 for the previous epoch, indicates that a high solar maximum has yet to be reached. The sun provides a concluding item of interest in the form of a total solar eclipse predicted for November 1, 1948. Its path has been computed for every minute during the passage of the shadow across Kenya Colony and the near neighbourhood of the Farquhar Islands. It will be a subject of special interest to the staff of the Radcliffe Observatory, at Pretoria, for whom charts and explanatory notes have been prepared at Greenwich.

ADHESIVES FOR METALS.—A bulletin issued by Messrs. Aero Research, Limited, Duxford, Cambridge, contains information regarding a new development in the bonding of metal to metal by resin adhesives. The Bulletin, No. 56, dated August, 1947, gives full particulars of the technique, tests and possibilities of this method of bonding in those fields in which thin metals are concerned, where riveting or welding is unlikely to give the desired results. As is usual in this series of technical bulletins, a bibliography is appended and reference is made to a survey of the subject of this type of bonding prepared by the U.S. Bureau of Standards.

THE EFFECT OF ATOMIC ENERGY ON SCIENTIFIC AND TECHNICAL PUBLICATIONS.*

By PROFESSOR R. E. PEIERLS, C.B.E., F.R.S.

RECENT developments have caused an enormous increase in the importance placed on science by the general public and by Governments. This is a help to science because it brings more support in the way of means and facilities; the price we pay for this is increased legislation limiting the freedom of scientists. Scientific progress has been accelerated in our generation largely because a thought expressed by someone, say, in Cambridge may at once lead to comments by a scientist in Copenhagen which show the right use for a machine available in Princeton. Restrictions on the international communications between scientists are restrictions on the progress of science in any country. Even if a country has progressed far enough in a subject to be able to ignore the contributions made anywhere else (and that is not true to-day of any country I know in any subject I know of) limits on publication would still hold up progress there, since the only efficient way of keeping people within that country informed is to rely on free publication and open discussion.

It is worth discussing in detail where we now stand, to what extent free discussion and publication are limited and what effect this will have in the immediate future. There are two laws which concern us here, the Official Secrets Act, and the Atomic Energy Act. The Official Secrets Act, passed in 1911 and amended in 1920 and 1939, is fairly generally known. Broadly speaking, it covers, for our purposes, the disclosure of secret information either by people who have been entrusted with the information, or who have obtained access to it by irregular means. Actually, the words "secret information" or "secret document" do not occur in the Act. Instead, reference is made to information about, or originating from, prohibited places (which includes now, for example, the Atomic Energy Research Establishment at Harwell) and alternatively to information which might be directly or indirectly useful to an enemy. Before anyone can be prosecuted under the Act it has to be established that what he did was for a purpose prejudicial to the interests or the safety of the State, though there is a clause providing that the proof of this may be rather indirect. In practice, it is usually understood that, as regards scientific or technical information, the material protected by the Act is the contents of documents labelled as secret papers, other work that, when completed is going to be incorporated in such secret papers, and current research work on which the investigators have been warned that it is secret work.

As regards atomic energy, the Act clearly covers all information in the possession of Government employees, and of consultants employed by the Government, as well as any information surreptitiously obtained. In addition to this, there is the secrecy clause in the Atomic Energy Act. Since this provides smaller penalties it will, in general, not have any effect except in situations to which the Official Secrets Act does not apply. There must be situations in which the knowledge does not come from official sources; a physicist working in a university laboratory may have made, quite independently and without knowing any official secrets, a new important discovery. Under the Atomic Energy Act it may be illegal for him to publish his results, or even to discuss them with a colleague. A publisher who would publish his paper would also be committing an offence.

Here the distinction between what is secret and what is not is not as straightforward as in the other case; the inspiration does not come to the inventor with the label "Secret" on it, nor does a Geiger counter show a red glow when it is measuring a new effect that is secret. The law, therefore, must contain a definition of the secrets to be kept so that all scientists (or at least those capable of understanding legal language) should know what they are not supposed to do.

The definition, in the case of the Atomic Energy Act, is surprisingly wide. The secrecy clause mentions mainly information about actual or proposed plants for the production of atomic energy. Upon reading this casually, every scientist was breathing a sigh of relief, since it is clear that nobody would seriously claim it as essential to the freedom of scientific discussion to be able to disclose, say, construction details of the plants at Hanford or of the new plant that the Ministry of Supply is proposing to set up in this country. Unfortunately, the Act also provides explanations of the words used in it; and almost every word means something rather different from what it usually means. The word "plant" means everything from a screwdriver up; it certainly covers any physical or chemical apparatus and, of course, machinery like cyclotrons. The words "production of atomic energy" are defined in a way which includes any nuclear reaction, such as Rutherford's original experiment on splitting the atom, only natural radioactivity being specifically excepted. Moreover, production of atomic energy also includes any preparatory activity. This might, for example, mean the separation of isotopes. The word "proposed" is not explained, but apparently if I publish a new design for an atomic pile, I am thereby proposing such a pile.

There are some qualifications. It is not an offence to repeat what has already been published—provided it was published without violating the Atomic Energy Act. This clause, therefore, protects the newspaper which reprints an article from a foreign Press agency, regardless of origin (since a foreign Press agency cannot violate the British Atomic Energy Act) but not the reporter who publishes a report of a meeting at which a professor or a civil servant may have committed an indiscretion, or the editor of a journal who accepts a paper that goes too far. A further concession is that the prohibition does not apply to information on methods which are in general use for other purposes than the production of atomic energy, unless they give away, by implication, important construction details of atomic energy plants.

All this, however, applies only to information given away "without consent of the Minister"; this means the Minister of Supply. There is provision for the Minister giving such consent, as it were, in bulk, by making an Order exempting certain classes of information. Such an Order has been made, and is of very far-reaching effect. If I may attempt to paraphrase the contents of this Order, it frees all information about nuclear reactions, methods of observing them and machines to produce the necessary radiations, with the sole exception of divergent chain reaction involving the fission of heavy elements.

This exemption applies only to the Atomic Energy Act. Some of this information may well be part of the knowledge embodied in secret reports; anybody with access to these is still prevented from disclosing them by the Official Secrets Act. No similar exemption Order has been made in respect of information other than nuclear physics, such as the chemistry of uranium and other substances, methods of isotope separation, etc., which may be subject to the secrecy clause of the Atomic Energy Act. It is very hard to ascertain how far the clause actually covers such material. This, briefly, is the law. The Atomic Energy Act, with the exemption Order, attempts to circumscribe by legal definition the kind of information to be kept secret.

The Official Secrets Act relies on instructions to Government employees and there must, therefore, be an administrative machinery to decide what is to be regarded as secret information. In other words, someone has to put a rubber stamp "Secret" on a new report, and someone must take the responsibility for deciding when a report no longer needs the protection and can be, as it is called, "declassified." The general principle of such declassification is quite clear. The intention which has been laid down as the policy of the appropriate Government departments is to release as much of the basic scientific data as is possible and thus to interfere as little as possible with the free interchange of scientific ideas on which the progress of science depends. This is limited, however, by keeping secret all material which has a direct bearing on the design and construction of atomic weapons and all plants producing atomic fuel. It is hoped that this secrecy can be relaxed when there is a satisfactory scheme for preventing, through international control, the misuse of atomic energy for destructive purposes. It is hoped that the countries which at present possess all the detailed knowledge about these matters—and this means at present, the United States and, to a lesser degree, this country and Canada—can facilitate the achievement of international control by offering the free exchange of all this information in return for concessions by others which would lead to a satisfactory scheme of international control.

There is an enormous difference between stating a policy in general terms and implementing it by an actual ruling as to the release or "declassification" of some particular piece of information. It has, in fact, proved impossible to devise a set of hard-and-fast rules which would tell any worker on the project what part of his information he can freely discuss with others or mention in publications and what part is to remain secret. Instead, machinery has been set up by which reports containing such information are scrutinised by experts, called "responsible reviewers," who recommend whether each report can be released. These reviewers must, of course, act on instructions which are embodied in a set of general rules for their guidance. These rules explain not merely what can be released, but also which parts are to remain secret; even so, in practice a report one examines never falls precisely into any of the categories set out in the rules. The job of the reviewer is to understand the purpose of the rules and to apply them intelligently.

(To be continued.)

* Paper delivered at the Aslib Annual Conference held in London on September 19-21, 1947. Abridged.

FLYING DISPLAY OF BRITISH AIRCRAFT.

(*Concluded from page* 283.)

THE Merganser, illustrated in Fig. 8, on page 300, and previously mentioned, is a feeder-line aircraft manufactured by Messrs. Percival Aircraft Limited, Luton, Bedfordshire, and during the flight demonstration it showed remarkably good handling qualities. It is of all-metal construction and, as will be apparent from the illustration, is a high-wing monoplane fitted with two engines and a tricycle-type undercarriage. The high-wing form of construction gives easy access to the cabin and, in addition, allows the passengers an uninterrupted view of the ground when flying, which is a not-unimportant consideration as it assists in avoiding glare. The machine has a span of 47 ft. 9 in. and an overall length of 39 ft. 8 in. The wing is of simple construction having two spars, each of which is built up from angle-section light-alloy extrusions bolted back-to-back to a reinforced plate web to form an I-beam. Monocoque construction is employed for the fuselage, the frames being made from light-alloy Z-section extrusions, while the stringers are channel-section extrusions with outwardly-turned edges, the light-alloy sheeting being flush riveted to the stringers.

The fuselage of the standard machine is divided into three compartments, the pilot's compartment, the passenger cabin with room for six passengers, and a baggage compartment. The latter is situated between the pilot's compartment and the passenger cabin, and has a floor area of 22 sq. ft. which gives a total capacity, of 110 cub. ft. Access to this compartment is gained either from the passenger cabin or through a 3-ft. wide loading door situated in the port side of the fuselage. The passenger cabin has an overall length and width of 15 ft. and 5 ft. 6 in., respectively, while the fuselage is of sufficient height to give 6 ft. headroom in the cabin. The toilet is situated at the after end of the passenger cabin and is designed so that it can be removed, together with the after bulkhead of the luggage compartment, when the machine is required for the carriage of freight. The after bulkhead of the luggage compartment can also be removed and the space used to carry two extra passengers when the aircraft is used on short hauls. Access to the passenger cabin is through a 2 ft. 3 in. wide door located at the after end and on the port side of the fuselage; the entrance is constructed so that, when loading freight, the width can be increased to 4 ft. by opening an additional door.

An interesting feature of the design is the method by which the wings are attached to the fuselage. The roots of each wing spar are provided with upper and lower lugs and each set of lugs is pinned to two machined light-alloy forgings which form part of the fuselage main structure. The forgings extend across the fuselage and act as main frames down to shoulder height. The floor of the cabin has been reinforced so as to withstand any concentrated loads likely to be imposed when the freight is carried. The tricycle undercarriage is retractable and the main units are mounted at, and retract into, the engine nacelles, the track being 15 ft. The three wheels are retracted pneumatically and fairing doors enclose them when in the retracted position.

The all-up weight of the Merganser is 6,700 lb., and the disposable load 2,110 lb. The wing area is 319 sq. ft., which gives a wing loading of 21 lb. per square foot, while the power loading is 11·35 lb. per horse-power. It is powered by two de Havilland Gipsy Queen 51 engines arranged to drive constant-speed feathering propellers, each engine developing 296 horse-power at take off. The maximum speed at sea level is 180 miles an hour, and at an altitude of 5,000 ft., 193 miles an hour, while the maximum continuous cruising speed at an altitude of 5,000 ft. is 183 miles an hour, this figure falling to 180 miles an hour at an altitude of 8,000 ft. The economical cruising speeds at sea level and at altitudes of 5,000 ft. and 8,000 ft. are 150 miles, 160 miles and 167 miles an hour, respectively. The stalling speed with flaps down is 69 miles an hour, and the maximum rate of climb at sea level is 1,010 ft. per minute, the service ceiling being in the neighbourhood of 24,000 ft. With six passengers and the pilot, and a baggage allowance of 300 lb., the range is 600 miles, but at the expense of payload the range can be increased to a maximum of 800 miles.

The Aerovan light freighter, which is manufactured by Messrs. Miles Aircraft Limited, Reading, is now widely known and in view of its success it was to be expected that a larger machine of the same type would be produced. This has now been accomplished, and, in addition to their existing range of aircraft, Messrs. Miles Aircraft Limited, were exhibiting the Merchantman, which can best be described as a larger edition of the Aerovan, but having over twice the payload capacity and more than three times the power. The machine is of all-metal construction and is illustrated in Fig. 9, on page 300, from which it will be seen that it is a high-wing monoplane fitted with four engines and an exceptionally simple form of fixed undercarriage.

FLYING DISPLAY AT RADLETT.

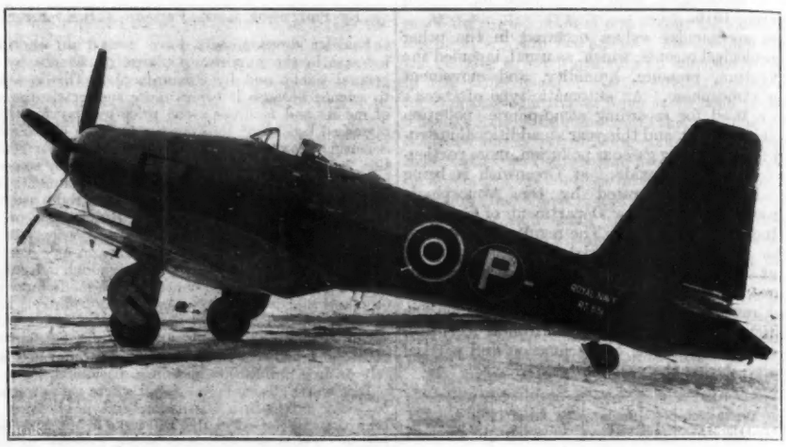


FIG. 10. DIVE BOMBER AND TORPEDO CARRIER; MESSRS. BLACKBURN AIRCRAFT LIMITED.

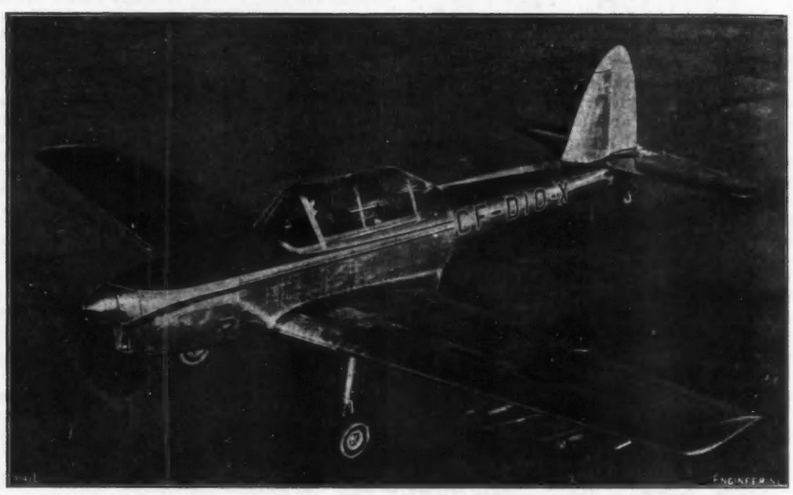


FIG. 11. "CHIPMUNK" TWO-SEATER TRAINER; MESSRS. DE HAVILLAND AIRCRAFT OF CANADA LIMITED.

The wing, which has a span of 66 ft. 6 in., is a simple structure built round a single spar having extruded flanges and a plain metal web; it is constructed in three pieces so as to facilitate repair operations and packing for shipment. The wing and tail are joined together by a simple box-type boom, while the tail unit is similar to that fitted on the Aerovan; the overall length of the complete machine is 42 ft. 9 in. The main fuselage or freight hold is slung below the wing, and the floor of the hold is stressed for concentrated loads; the floor also serves as a chassis for the fixed tricycle-type undercarrriage. The bottom of the fuselage is close to the ground and a built-in ramp facilitates the loading of freight; as on the Aerovan, the rear portion of the fuselage swings to one side as a complete unit.

The main cabin has a total capacity of 780 cub. ft., the main inside dimensions being 18 ft. long, 7 ft. 3 in. wide and 6 ft. 6 in. minimum height. It is possible to transform the Merchantman from a freighter to a 20-seat passenger-carrying aircraft, and the manufacturers claim that this can be accomplished in a matter of ten minutes. Although designed specifically for the carriage of freight, provision has been made for the fitting of additional sound-proofing material should the aircraft be required for use as a passenger carrier only.

The Merchantman is powered with four de Havilland Gipsy Queen 30 six-cylinder engines, each of which has a maximum rating of 250 brake horse-power. The maximum all-up weight is 13,000 lb. and the payload, when carrying 100 gallons of fuel, is 5,000 lb. The estimated range at 5,000 ft. on maximum cruising power is 686 miles in still air, while at sea level this figure falls to 626 miles. At full load, the service ceiling is 16,000 ft. and the absolute ceiling approximately 17,400 ft. The maximum level speed at sea level and at altitudes of 5,000 ft. and 10,000 ft. is 163 miles, 157 miles, and 149 miles an hour, respectively.

Another new machine exhibited by Messrs. Miles Aircraft, Limited, was an experimental freighter aircraft bearing the type number M.68. This machine is illustrated in Figs. 6 and 7, on page 300, and a unique feature is the removable fuselage hold which fits between the cabin and the faired tail. In Fig. 6, the removable hold or container is in position, while Fig. 7 shows the aircraft in flying trim but without the container. In addition to being removable, the container is fitted with detachable road wheels and a towing bar, which enable it to be used as a trailer for transport between the airport and the final destination. Obviously, more than one container can be used in conjunction with a single aircraft, and by this means the handling of freight is reduced to a minimum, while the turn-round of the aircraft is greatly expedited. It should perhaps be mentioned that the machine can be flown either with or without the container, and was flown in both conditions during the display.

The design of the M.68 is based on the Miles Aerovan, but it is fitted with four Blackburn Cirrus Minor engines and therefore comes within a class somewhere between the Aerovan and the Merchantman. The span is 50 ft. and the overall length 36 ft., while the standard container has a length of 10 ft., the width and height being equal at 4 ft. 6 in. In view of the fact that the container is detachable, the undercarriage is arranged differently from those on the Aerovan and the Merchantman, the fixed main legs of the tricycle undercarriage fitted to the M.68 projecting through the inboard engine nacelles. The four engines each develop 100 brake horse-power, and at a cruising speed of 130 miles an hour and carrying a payload of 1,600 lb., the still-air

TURBINE ENGINES AT RADLETT FLYING DISPLAY.

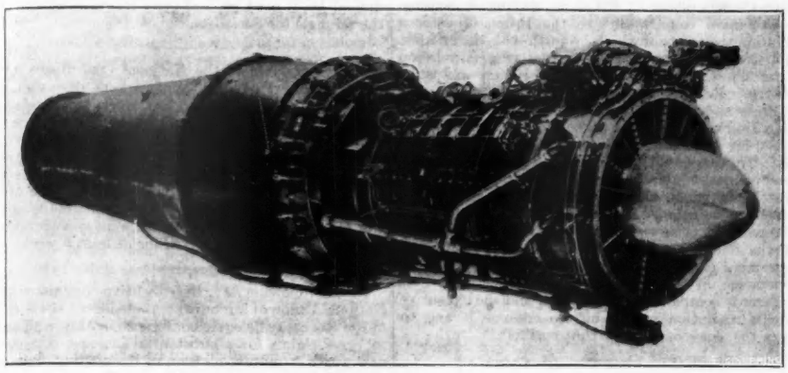


FIG. 12. "BERYL" JET ENGINE; MESSRS. METROPOLITAN-VICKERS ELECTRICAL CO. LIMITED.

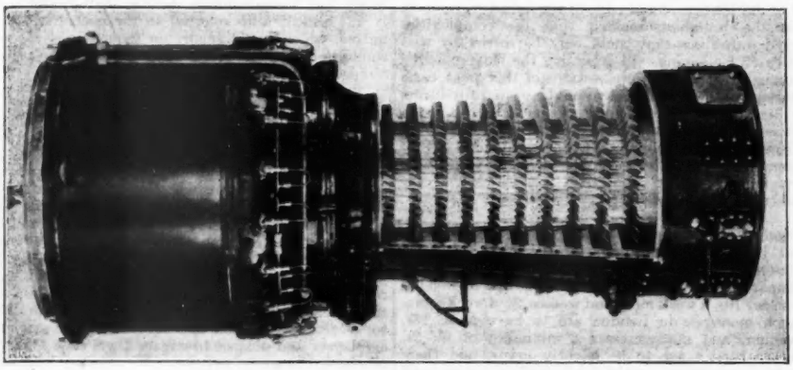


FIG. 13. COMPRESSOR FOR "BERYL" ENGINE; MESSRS. METROPOLITAN-VICKERS ELECTRICAL CO. LIMITED.

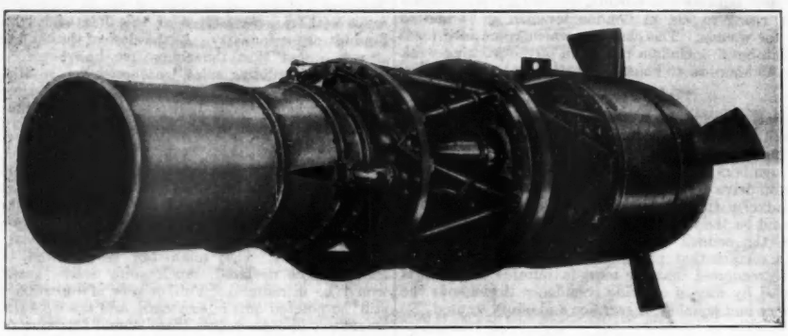


FIG. 14. "NAIAD" GAS-TURBINE ENGINE; MESSRS. D. NAPIER AND SON LIMITED.

range is 400 miles. The fuel capacity is 100 gallons, which gives a maximum still-air range of 800 miles.

With the exception of the Hastings Mk. I, all the new aircraft described so far are civil machines. It must not be assumed, however, that development has been confined to this type only, as several new types of military and naval aircraft were demonstrated, notably the Wyvern Mk. I naval torpedo fighter and the S28/43 dive-bomber and torpedo carrier. The Wyvern is manufactured by Messrs. Westland Aircraft, Limited, Yeovil, Somerset; it is an all-metal, low-wing, single-seat machine, but as it is still on the secret-list it is not possible to give details except that it is powered by the Rolls-Royce Eagle 24-cylinder, sleeve-valve engine, particulars of which were given in ENGINEERING, vol. 163, pages 102 and 380 (1947).

The S28/43 is manufactured by Messrs. Blackburn Aircraft Limited, Brough, Yorkshire, and has been designed specifically for dive-bomber and torpedo operations. The machine is illustrated in Fig. 10, opposite, from which it will be seen that it is a single-seat low-wing monoplane. It is of all-metal construction and is powered by a Bristol Centaurus 59, which is an 18-cylinder double-row radial air-cooled engine fitted with sleeve valves and a two-speed supercharger. Engine cooling is assisted by a fan mounted on the spinner backplate and a water-methanol injection system is fitted. The wings are arranged to fold upwards and over, two distinct breaks being made in each wing, the inboard one at the wing roots while the outboard break occurs approximately midway between this point and the wing tip. The fuselage construction follows the usual Blackburn practice, in that it is made in two parts, the rear part being of monocoque construction while the forward part is of tubular construction and has channel-section longitudinal side members. Both the tailwheel and the undercarriage are retractable, the undercarriage retracting inwards into the centre plane. Power for this purpose is provided by an engine-driven hydraulic pump and a mechanical release is fitted for use in case of failure of the hydraulic system. The aircraft has a span of 45 ft. and a length of 39 ft. 4 in.

Hitherto the aircraft exhibited each year have been manufactured in the United Kingdom, but under the society's Memorandum of Association, the word "British" includes the Dominions and all British Colonies. This interpretation resulted in the appearance of the Chipmunk, a two-seat training and private plane designed and manufactured by Messrs. de Havilland Aircraft of Canada Limited, Toronto. The Chipmunk is illustrated in Fig. 11, opposite, from which it will be seen that it is a low-wing monoplane with fixed undercarriage. It has been designed as a primary trainer, and for this reason tandom seating was decided on to ensure good aerobatic qualities together with maximum performance.

With the exception of the wing covering aft of the main spar and some of the control surfaces, the machine is of all-metal construction. The stressed-skin fuselage is made in two separate parts which are joined to each other at a point immediately aft of the rear cockpit by a reinforcing band which encircles the fuselage and to which the two parts are riveted. The forward section is built round four main longerons which are carried on pressed formers, a series of modified Z-section stringers being interspersed between the longerons. The wing-attachment points fit on to a U-shaped frame located beneath the front cockpit, and this frame transmits the spar loadings across the fuselage. The cantilever wing is made in two main panels, each of which is fitted to the fuselage at three points, namely, the top and bottom of the main spar and the leading edge. Each wing panel incorporates an all-metal D-nose box beam consisting of the main spar, the nose ribs and the leading-edge covering. The box beam is designed to take all the wing stresses as well as the undercarriage loads and metal covering is employed; fabric is used, however, to cover the wing aft of the main spar. The fin and tailplane are of all-metal construction, but the rudder, elevators, ailerons and flaps consist of fabric-covered pressed-metal ribs and spars.

The method of mounting the engine is a new departure for the makers. Iu owrder to give good accessibility, built-up light-alloy beams are bolted to the upper longerons of the fuselage and each beam is connected to the lower longerons through struts. The undercarriage is fitted with rubber shock absorbers, the main legs of the undercarriage being fitted directly to the wing nose. The wheels are fitted to cantilever axles and the brake-operating mechanism is connected into the rudder-control system. The machine is powered by a de Havilland Gipsy Major 10 engine, which develops 140 brake horse-power at 2,400 r.p.m., at sea level. At the present time, the Chipmunk is fitted with a fixed-pitch propeller, but it is intended to fit the de Havilland manually-operated variable-pitch propeller at a later date.

The maximum speed of the Chipmunk is 143 miles an hour at sea level and 139 miles an hour at 5,000 ft., the corresponding cruising speeds being 124 miles and 122 miles an hour, respectively. The rate of climb at sea level is 900 ft. per minute and this figure falls to 460 ft. per minute at 10,000 ft.; the service ceiling is 19,000 ft., while the absolute ceiling is 21,000 ft. The machine has a range in still air of 485 miles and the fuel consumption at cruising speed is equivalent to 19·4 miles per gallon. A feature of the aircraft is the low stalling speed, which, with flaps down, is stated to be 40 miles an hour, and it is interesting to note that the Chipmunk, although fitted with a similar engine to the Tiger Moth, is nearly 40 miles an hour faster than this machine.

There were, of course, many more aircraft on view than it has been possible to describe here, and it is emphasised that those described have been selected, not because they are considered better than their contemporaries, but purely because they have not been described previously in ENGINEERING. The same remarks apply to the static exhibition; lack of space alone prevents a detailed description of the exhibits from being given, but mention may be made of the Beryl jet-propulsion engine manufactured by Messrs. Metropolitan-Vickers Electrical Company Limited, Manchester, and the Naiad gas-turbine engine manufactured by Messrs. D. Napier and Son, Limited, London, W.3, as neither of these two engines has been described previously in ENGINEERING.

The Beryl engine is illustrated in Fig. 12, on this page, which is a general view of the engine, and in Fig. 13, which shows the engine with one half of the compressor casing removed. It will be seen from Fig. 13 that the compressor is of the axial-flow type, and the Beryl is the first axial-flow jet engine to have completed satisfactorily a type test to the Ministry of Supply official schedule; it has been rated at 3,850 lb. take-off thrust at 7,700 r.p.m. It has an overall diameter of 37·9 in. and an overall length of 13 ft. 3 in., while the weight dry is 1,750 lb. Two of these engines have been fitted to the SR/AI flying-boat fighter manufactured by Messrs. Saunders Roe, Limited, and an illustrated description of this machine will be found on page 140, *ante*.

In its main essentials, the Beryl engine is similar to the jet engine used as a gas producer for the gas turbine installation in M.G.B.2009, which was described on page 271, *ante*. In operation, air enters the compressor through the intake guard visible to the right

of Fig. 12, and passes into the axial-flow compressor, which has ten stages, and is illustrated in Fig. 13, on page 307. After compression, the air flows through a diffuser situated at the outlet from the compressor, where the flow is divided at the entry to the combustion chamber. The combustion chamber is of the annular type and consists of two concentric containing walls forming an annulus, within which is mounted an annular primary chamber having inner and outer walls. Air entering the chamber from the compressor is divided, the smaller portion entering the zone of primary combustion through a series of holes in the upstream end of the primary chamber, while the larger portion passes to the inner and outer annuli formed between the primary chamber and the containing walls. The fuel is injected into the primary chamber in an upstream direction through 20 fixed-orifice jets and the products of combustion in the primary chamber are then mixed with the remainder of the air, which enters the chamber through a series of slots formed in the inner and outer walls. The gases then pass through the single-stage turbine, which drives the compressor, the residual energy in the gases being used to form a high-velocity propulsive jet.

The complete rotor is carried on two ball races and it consists of the compressor drum together with the moving blading, the extension piece in way of the combustion chamber, and the turbine wheel. The turbine wheel is overhung from its bearing and is machined from a molybdenum-vanadium steel forging, while both the fixed and moving blades of the turbine assembly are of Nimonic 80 alloy. The moving blades are fitted to the turbine wheel through serrated roots and the fixed blades are riveted to the turbine diaphragm. The compressor rotor and the extension piece are light-alloy forgings and this material is used also for both the fixed and moving blades of the compressor, the fixed blades being dovetailed into axial grooves formed in the casing while the moving blades are located in serrated slots in a manner similar to the turbine blades. The compressor stator, together with its inlet and outlet castings, is of light alloy and the engine auxiliaries are mounted externally on the compressor casing. As the turbine bearing is enshrouded by the combustion chamber, provision has to be made for cooling and this is effected by delivering a small quantity of air bled from the fourth stage of compression to both the rotating and stationary bearing housings. The forward and after bearings are lubricated by oil spray, which is entrained in low-pressure air bled from an intermediate stage of the compressor.

The engine burns kerosene, but other fuels have been used successfully. Compensation for the varying fuel demands at different altitudes is provided for automatically by a relief valve fitted into the fuel system, in which is incorporated a barometric capsule. The fuel-control system has been designed so as to ensure automatic regulation of engine acceleration, and the only control with which the pilot of an aircraft is concerned during flight is the engine throttle lever. Starting is accomplished either by a small electric motor or a Plessy two-stroke petrol starter; usually, the starting motor is fitted externally, but it can be housed in the nose cap at the front of the compressor.

It was to be expected that Messrs. D. Napier and Son Limited, Acton, London, W.3, would soon enter the gas-turbine field, and the exhibits on their stand in the static exhibition included their new gas-turbine engine, the Naiad, which is illustrated in Fig. 14, on page 307. As will be apparent from a study of this illustration, the engine is designed for use in conjunction with a propeller. Unfortunately, the Naiad is still on the secret list, so it is only possible to give brief details. It can be stated, however, that it is fitted with an axial-flow compressor, which delivers the compressed air to five combustion chambers. Although designed for use with a single-rotation constant-speed propeller, additional thrust is provided by the exhaust gases, and the propelling nozzle is provided with a two-position control for take off and climb and level flight. The air intake to the compressor is in the form of a hollow spinner on the propeller, the shanks of the propeller blades being enclosed by streamlined fairings. Perhaps the most notable feature of this engine is its exceptionally small size; the maximum diameter is only 28 in. and the length from the nose of the spinner to the turbine outlet flange 8 ft. 6 in. The maximum estimated take-off power is 1,590 brake horse-power at a speed of 18,250 r.p.m., while the maximum cruising power is 1,005 brake horse-power at 17,000 r.p.m.; both these figures include the thrust of the jet. The usual auxiliaries, such as 24-volt electric starter, fuel pumps, etc., are fitted, and a shaft having a capacity of 50 h.p. is provided for driving an ancillary gearbox.

Generally, the exhibits in the static exhibition were of a high order and the wide range of accessories shown served to illustrate the importance of the aircraft-component industry in this country. Both the display and the exhibition left the impression that the aircraft industry has overcome, to a large extent, the difficulties imposed in recent years.

LABOUR NOTES.

THIS editorial note appears in the September issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation: "Following its August meeting, the executive council sent to the Prime Minister a resolution the terms of which set forth with the greatest simplicity and clarity exactly where it stood in relation to the question of nationalising the iron and steel industry. Reports appearing in various sections of the Press had implied that there was no demand for nationalisation from the workers, and some had even gone so far as to assert that we were actually opposed to it. Nothing could be more remote from the truth. There cannot be, and never has been, the slightest doubt as to where the Confederation stands on this momentous question. More than a year ago—in June, 1946, to be precise—we said in this column: 'Now that the decision to nationalise has been made, the Government can depend upon the full support and the co-operation of the workers in the industry.' This statement is completely unequivocal, and the executive council's resolution served but to endorse it and to convey the sense of urgency that was felt."

"We cannot truthfully say," the writer of the editorial note continues, "that we are completely satisfied with the Government's handling of the matter, but, out of our intimate knowledge of the industry, we have from the beginning realised that its complexities offered difficulties that could only be solved by wise and careful planning. In accepting the Government's assurance that appropriate sections of this great basic industry will be transferred to public ownership during the life-time of the present Parliament, we do so on the assumption that a practical, workable, and foolproof scheme will be forthcoming. In the words used by the General Secretary at the Trades Union Congress, it must be 'something more than a side issue of the Ministry of Supply.'"

Increases of wages and a shortening of the working week have been agreed to by the National Joint Industrial Council for the retail drapery, outfitting and footwear trades. Men over 21 years of age in London are to get 10*s.* a week more and women 9*s.* a week more. Branch managers in London are to have a 5*l.* 18*s.* minimum, and manageresses a minimum of 5*l.* 2*s.* Provincial rates are to be slightly lower, and there will be proportionate rates for juveniles. Sales staff and clerical employees are to have a minimum scale according to age, ranging, in London, from 35*s.* for boys of 15 to 98*s.* for men at 24. Other employees, including packers and porters, are to have a minimum scale, rising to 90*s.* in London for men at 24 and to 67*s.* for women. The changes, which come into force on October 6, include a reduction of the working week from 48 hours to 46 hours. Overtime is to be paid for.

It was announced last week that the general executive council of the Transport and General Workers' Union had passed a resolution pledging the full support of the members of the organisation "in the all-out production drive designed to step up exports and so repair the adverse trade balance." Members were urged to respond to the call and play their part. At the same time, the council called upon the Government "to make certain that prices of commodities and profits are so regulated that the most favourable condition is effected by way of creating confidence throughout the country and equality of sacrifice and effort secured."

The Amalgamated Engineering Union have sent a message to their members in Britain calling for more production. The present economic crisis, it is stated, involves the working class to a degree unparalleled in the history of the nation. The greatest contribution to its solution is the extent to which productivity increases throughout the country. It is to be regretted, the message continues, that the President of the Board of Trade in his reference to restrictive practices gave no indication of the steps the Government proposed to take regarding practices operated by cartels, trusts, combines and monopolies. Notwithstanding that, the executive council expresses confidence that the members of the union will fulfil their responsibilities and make a 100 per cent. contribution to the solution of the crisis.

"Our members," the message goes on, "solved the problems of production during the grave years of war by their insistence upon the establishment of lively and realistic joint production committees, and it is fully recognised that without the full operation of such committees the difficulties of the present economic situation will be prolonged. While not being fully satisfied with the way in which the Government have handled this whole question over the last two years—having special regard to the memoranda and declarations issued by the union during this time—we call upon our members to enter into this new form of activity confident in the knowledge that they will give of their best, increase production, accept temporary difficulties, if need be, and press forward collectively in the struggle for Socialism."

Representatives of the National Coal Board and of the National Union of Mineworkers discussed at a conference on Wednesday last week the proposal of the union that production should be increased by working "systematic overtime" in whatever way individual pits found suitable. The extra work, it was stated, would be paid for at straight piece-work rates. An official communication issued after the meeting was to the effect that "considerable progress" had been made, and that further joint consideration of the matter had been deferred for at least a week.

On the following day, the executive committee of the National Union of Mineworkers considered the decisions of the Rothesay delegate conference in July, and agreed to press claims for a substantial increase of wages, a new wages structure, revision of the grading of employees, and supplementary pensions at 55. A wage increase of 2*l.* a week was talked about, but, according to Mr. Horner, the general secretary of the union, no specific figure had been definitely decided upon. The claims, it was added, were referred to the consultative committee, which would report on them to the executive committee on October 2. A national delegate conference has been called for October 3.

The new Control of Engagement Order—which is to have effect as from October 6—follows closely the provision of the old one. It applies to men between the ages of 18 and 50, and to women between the ages of 19 and 40 (except women with children under 15 years). Professional, administrative and managerial workers are outside the scope of the Order, and so are part-time employees. Provision is made for men released from the Forces to be free to choose their own jobs when they are on release leave. Those who are covered by the Order are allowed to get jobs only through a labour exchange. Employers are forbidden to advertise jobs except for exempted grades of employees and obliged to engage them only through a labour exchange.

The Government's plans for directing labour were discussed by Mr. Isaacs, the Minister of Labour and National Service, at a meeting on Wednesday last week with representatives of the Joint Consultative Committee for Industry. At the close of the conference, it was stated that the committee had agreed to a number of "guiding rules" proposed by the Minister for "a limited exercise of the existing power of direction in cases where this is indispensable to the effective working of the new order.

In the course of a statement on Thursday last week, Mr. Isaacs emphasised that direction of labour is to be used only as a last resort. He hoped and believed, he said, that the new regulations would meet the Government's manpower requirements to beat the economic crisis. They might fail, he admitted, but if they did, he declared, much more drastic measures would be introduced. Full powers of direction were still, he pointed out, in existence, and the Government would not hesitate to use them should the state of the nation make it necessary to do so. The Cabinet would review periodically the way the new regulations were working out, and if they served their purpose they would remain in force until the end of 1948.

Official figures relating to the coal-mining industry show that, in the week ended September 16, absenteeism was slightly less at 11·24 per cent. overall (5·39 per cent. voluntary and 5·85 per cent. involuntary), compared with 11·39 per cent. in the August 30 week. Among coal-face miners, absenteeism was 13·66 per cent. (6·37 per cent. voluntary).

It was announced officially in London, after a conference on Thursday last week between representatives of the National Coal Board and representatives of the National Association of Colliery Overmen, Deputies and Shotfirers, that the strike notices given by the Yorkshire members of the Association had been withdrawn. The dispute which led to the tendering of the strike notices arose over the conditions of deputies and others under the five-day week agreement. On behalf of the executive committee of the Yorkshire Deputies' Association, it was stated that the London negotiations were proceeding so satisfactorily that it was deemed undesirable to hamper them.

CREEP AND SHRINKAGE IN REINFORCED-CONCRETE STRUCTURES.*

By H. B. SEED.

THE non-elastic deformations which occur in concrete have been the subject of many investigations since their effects on the stress distributions and deflections of reinforced beams were first demonstrated by Dr. Oscar Faber in 1928, but, in spite of a great deal of research, very little has been published which is of direct assistance to the designer of reinforced-concrete structures. In this country, for example, apart from a modification in the D.S.I.R. Code of Practice with regard to reinforced-concrete columns, standard methods of design have remained comparatively unchanged during the last 20 years. During this period, however, a number of methods have been put forward by which the magnitude of creep and shrinkage effects in reinforced-concrete members can be calculated, and the object of this paper is to compare the relative merits of these methods with a view to their incorporation in routine procedure.

The application of load to a plain concrete specimen results in two distinct movements: (1) an elastic movement proportional to the applied stress, and (2) an inelastic deformation which increases progressively with time, but which is nevertheless approximately proportional to the applied stress for values up to about one third of the ultimate. As the loaded period increases the rate of deformation decreases, but some movement has been recorded after periods as great as ten years. It is this second non-elastic deformation under load which is referred to as the creep of concrete, although it is completely different by nature from creep as applied to metals. In the latter case, creep, or plastic flow, is the non-elastic deformation which occurs when the yield stress is exceeded, and is caused by slippage along planes within the crystals; this results in a considerable change in cross-sectional area but no change in volume. Dr. W. H. Glanville's tests at the Building Research Station have shown that, if there is a yield stress for concrete below which no inelastic deformations occur, the value of this stress is so small as to be negligible; and, further, that the lateral deformations accompanying longitudinal-creep movements in concrete specimens under ordinary working stresses are only about one tenth of those required for the volume to remain constant. The deformation cannot therefore be attributed to either plastic or viscous flow in concrete.

Apart from creep movements in concrete under load, a second non-elastic movement is also apparent: the progressive contraction which occurs in air-stored concrete under zero stress conditions, known generally as shrinkage. This movement too, is a function of time—it would appear, in fact, to be a similar function to that governing the rate of creep—but it varies across the section of a specimen, being greater at the surface than at the central axis. In assessing the magnitude of the inelastic movements, shrinkage is usually considered to be unaltered by the application of load to a concrete specimen and only those inelastic deformations in excess of the free shrinkage are attributed to creep.

In order to explain the various methods of calculating creep and shrinkage effects, it is desirable to indicate briefly the nature of these inelastic deformations. Several explanations are available, but the most generally accepted is that based on the solid solution or colloidal theory of cement composition. When water is added to a concrete mix it begins to dissolve the surface of the cement particles, forming (*a*) a colloid and (*b*) a series of solutions. As solution progresses heat is evolved, causing the colloid to form a gel of calcium silicate which acts as the binding agent between the aggregate particles; that is, the concrete starts to set. For this reason, hot water hastens the setting of cement. Meanwhile, more water attacks the cement particles and the mixture consists of colloid, gel, solutions, and free water which has not yet reached the surfaces of the particles. This water may be squeezed out of the concrete while casting, or lost by evaporation during setting. New colloid, as it is formed, is absorbed by the gel, but when the mixture begins to dry out the solutions evaporate, and crystals of calcium sulphoaluminate and calcium hydroxide are formed in the minute crevices or micropores which are present in the gel structure.

Thus the water content of concrete can be subdivided into three main types: (*a*) firmly held or chemically-combined water, as in $Ca(OH)_2$; (*b*) loosely held such as colloidal water; and (*c*) mechanically held or free water. The proportion of free water, initially high, is reduced considerably by losses in evaporation and the constant hydration of cement, while the proportion of loosely-held water in the colloid or gel is progressively reduced by the conversion of the gel to a more stable crystalline form. As a result, the water becomes more firmly held with age, the concrete hardens, and the gradual crystallisation causes a corresponding slight change in the physical properties, an increase in strength, and a reduction in elastic strain under stress.

The binding agent in concrete, therefore, is largely composed of cement gel, and the property of gels when wetted to take up liquid and swell, or when dried to give up liquid and contract, has been firmly established. If, then, water is removed from the gel constituent of concrete, a contraction of volume is to be expected. Mortar retains the property of expanding and contracting on wetting and drying after many years and, since aggregates exhibit little or no inelastic deformation, it is clear that all such movements in concrete must take place in the cement paste. In an unloaded specimen, cement gel at the surface loses water by evaporation and replaces some of this from the moister concrete inside, so forming a moisture gradient across the concrete. Since the volume of the gel is a function of the moisture content, shrinkage will vary across the specimen, being greatest at the outer surface and least at the central axis.

When concrete is wetted, these conditions are reversed; the specimen lengthens as a whole, but the greatest movement takes place at the outer surface. Tests by A. H. White have shown that, up to ages of at least 20 years, mortar and concrete respond quickly to variations in moisture conditions, though the rate of change is not so great as in a freshly-cast specimen. Volume change seems to depend less on the quantity of water entering or leaving a specimen than on the manner in which it is held. It has been shown that concrete takes up a certain amount of water before it begins to expand and goes on expanding slowly after it has ceased to absorb water. Mr. White also showed that concrete will take up a fair weight of benzene without any effect on the linear dimensions and, since this could not be chemically combined or absorbed by the colloid, it could only have been stored in the capillary channels or micropores of the concrete. This implies that free water has no effect on the movement, which is mainly due to change of moisture content of the gel or to its subsequent conversion to crystals. It suggests, too, that a wet concrete will lose a certain amount of water before it begins to contract; a result demonstrated experimentally by Professor A. D. Ross.

It has been explained already that only about 10 per cent. of the creep movement occurring in a loaded concrete specimen can be identified with either plastic or viscous flow. The results of all investigations have shown, however, that the rate of creep is materially affected by the age of the specimen and by the moisture conditions under which the measurements are made. The only constituent of concrete which changes with age and is influenced by moisture conditions is the cement gel, and it is the changing nature of this constituent, therefore, to which the phenomenon of creep must be attributed. This being the case, an adequate explanation is provided in terms of seepage in colloidal systems.

The vapour pressure of the liquid in a gel is influenced by stress and the application of load results in an immediate increase in vapour pressure. In order to restore this to the particular value corresponding to the external conditions, moisture is expelled from the gel until an equilibrium position is reached; that pressure does have this effect was shown by Abrams, who expelled large quantities of water from concrete by loading it during setting, while Lendren was able to squeeze 599 parts out of 600 from silicic-acid gel. Now, in a system composed of an elastic solid and a viscous fluid and subjected to pressure, the fluid will tend to squeeze out, throwing a progressively increasing stress on the solid and a gradually decreasing pressure on the fluid. This will result in a corresponding reduction in the rate of expulsion of the fluid. This type of flow is a common phenomenon in colloidal systems, known as seepage.

The creep of concrete is consistent with seepage of water through the gel. Under pressure, water is expelled from the gel, the concrete becomes a mixed system and the moisture tends to seep away through the membranes of the gel or the micropores. The rate of expulsion is reduced as the load is gradually transferred to the aggregate particles, but it is also affected by the rate at which the expelled water can seep away. With a low rate of seepage, the internal humidity of the concrete will be high and moisture expulsion will tend to be reduced; with a high rate of seepage, on the other hand, moisture expulsion will be facilitated. Thus the rate of creep will be a function of the applied pressure, the quantity of moisture in the gel, the rate of seepage, and the moisture conditions surrounding the gel; any factor which influences these conditions, in consequence, will affect the magnitude of the creep movements. For a given pressure and constant moisture conditions, for example, the rate of creep will be higher for a weak gel (corresponding to a high water : cement ratio) than for the same concrete mixed with a low water : cement ratio; similarly, for a given concrete and stress, creep movements will be greater in dry surroundings where moisture extraction is encouraged than in a humid atmosphere where the expulsion of moisture is more effectively repelled. These points may be illustrated by a test carried out by Professor R. E. Davis at the University of California. A concrete specimen was dried in an oven to constant weight, varnished to keep out moisture, and then maintained under constant load. While the specimen remained in this dry state there was practically no movement, but after the initial period the moisture potential between the atmosphere and the specimen was so great that the specimen took in water through the varnish coat and expanded against the load. In this case, the vapour pressure of the gel was so low that, even despite the application of stress, it was necessary to absorb water to restore the equilibrium between the gel and its surroundings.

It will be seen from the above description of the inelastic deformations that the creep and shrinkage movements in a concrete specimen, which are determined mainly by the applied stress, the quantity of the moisture in the gel, the rate of seepage and the moisture conditions surrounding the gel, will be influenced by a number of variable factors. These include the water : cement ratio, the type of cement, the type and grading of the aggregate, the proportions of the mix, the size of the specimen, the curing conditions, the humidity and temperature conditions in which the specimen is maintained, the magnitude of the applied stress and the age at loading in the case

Fig. 1.

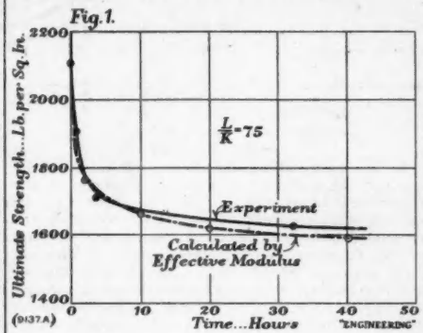


Fig. 2.

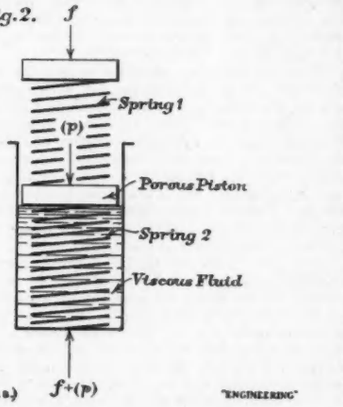
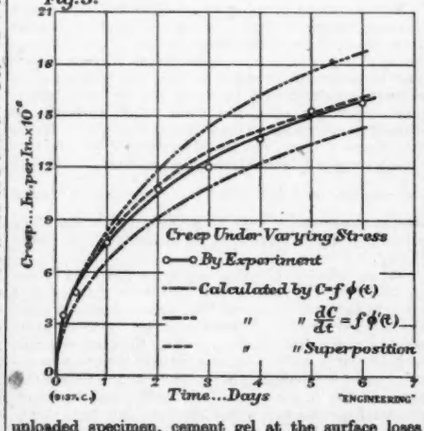


Fig. 3.



* Paper read before Section G of the British Association at Dundee on Monday, September 1, 1947.

CREEP AND SHRINKAGE IN REINFORCED CONCRETE.

Fig. 4.

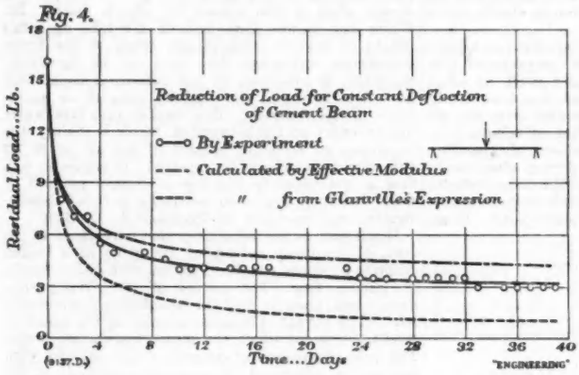
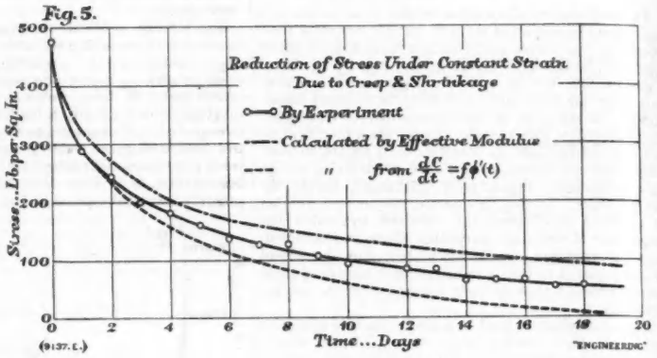


Fig. 5.



of creep, and the age of the concrete at the time of the first observation in the case of shrinkage. The effects of these factors have been studied in a number of comprehensive investigations by Professor R. E. Davis. Under given conditions, however, a particular concrete specimen will possess definite creep and shrinkage properties, the deformation at any time depending only on the magnitude of the applied stress, and it is by measurement of these properties that the effects of the movements in reinforced-concrete structures must be deduced.

In this respect, shrinkage presents comparatively little difficulty, since its magnitude is considered to be unaffected whatever the stress to which the concrete is subjected. Therefore, it can be measured directly on an unloaded specimen and included in the analysis of a structural problem. Unfortunately, the magnitude of creep movements in concrete structures cannot be obtained so easily. The creep properties of concrete almost invariably are measured by observing the deformations which occur in a plain specimen under constant sustained axial load and, under these conditions, it has been demonstrated by numerous investigators that the creep movement, for all practical purposes, is proportional to the applied stress, provided this does not exceed the ordinary working values used in design. This result is of special importance since it provides a simple method of calculating creep effects. If e is the elastic strain of the concrete under unit stress and c is the creep strain of the concrete per unit sustained stress after any particular time, the total deformation at this time under a stress f would be $f \times e + f \times c = f(e + c)$. This is equivalent to the result obtained by assuming the concrete to possess an effective modulus of elasticity of value $\frac{1}{e+c}$, in which case the total strain $= \frac{\text{stress}}{\text{effective modulus}} = f(e + c)$, as before. Hence the effects of creep on the form of members in which the concrete stress is maintained constant can be calculated simply by substituting the appropriate value of the effective modulus in the ordinary elastic equations.

Such conditions, however, are rarely, if ever, encountered in practice and can never occur in reinforced-concrete members. The distribution of stress in a composite member is governed by the strains in the materials, and thus in a reinforced-concrete member, even under constant load, there will be a continuous re-distribution of stress due to the progressively increasing creep and shrinkage deformations. This will usually result in a reduction of stress on the concrete, though an exception may occur in the case of long columns, and a corresponding increase in stress in the steel. In this case, then, creep movements occur under a progressively varying (usually decreasing) stress, the deformation and stress being interdependent, and it becomes necessary to calculate the magnitude of either the creep movement or its effects under these conditions from the deformations measured on plain concrete specimens under constant axial load. For this purpose, the following methods have been suggested.

It has been explained that the creep movement in a given concrete specimen under constant stress both increases with time and is directly proportional to the stress. It follows that, under these conditions, the magnitude of the deformation can be represented by the equation $C = f\,\phi\,(t)$, where C is the creep after a time t, f is the stress and $\phi\,(t)$ is some function of time; and also that the rate of creep at any time,

$$\frac{dC}{dt} = f\,\frac{d}{dt}\,\phi\,(t) = f\,\phi'\,(t),$$

is directly proportional to the stress.

In this method of calculating creep movements under varying stress, which was originally suggested by Dr. Glanville, it is assumed that the rate of creep at any instant is independent of any stress to which the concrete has been subjected previously and is represented, therefore, by the above expression. This can be incorporated readily in the analysis of reinforced-concrete beams and columns by considering the changes taking place in an element of time, Δt, and the overall effects obtained by integration; in the case of columns this can be done directly and the term $\phi\,(t)$ in the resulting exponential expression obtained from a constant-stress creep test, but for beams it is necessary to use a graphical process for integration.

The effects of creep calculated in this way have been shown to be in good agreement with experimental results, but small errors would be expected in view of the initial assumption. It seems improbable, for example, that the rate of creep after one month in a specimen which has been maintained under a constant stress of 200 lb. per square inch will be equal to that in a specimen on which the stress has been gradually reduced over this period from 750 lb. to 200 lb. per square inch. It appears reasonable, in accordance with the mechanism of the inelastic movements, to expect a lower rate of creep in the latter case. The moisture expelled by a sustained load of 200 lb. per square inch should be less than that expelled by a load which is at all times greater than 200 lb. per square inch; the specimen under varying stress should therefore contain a lower proportion of moisture and, in consequence, exhibit a lower rate of creep. Hence, under decreasing stress conditions, the assumption of equal rates will lead to over-estimation of the magnitude of creep movements and effects.

In the method of using an effective modulus, which possesses the great advantage of simplicity, it is assumed that the constant-stress creep equation $C = f\,\phi\,(t)$ can be applied to creep movements under varying stress; that is, whatever the stress variation to which a plain concrete specimen may be subjected, the creep movement after any particular time under load will be directly proportional to the stress at that time. Hence the effects of creep can be calculated, as for constant stress, simply by substituting an appropriate value of the effective modulus, equal to $\frac{1}{e + \phi(t)}$, where e is the elastic strain under unit stress and $\phi\,(t)$ is the creep strain per unit sustained stress, in the ordinary elastic theory.

Values calculated in this way have also been shown to be in good agreement with the measured effects of creep in reinforced-concrete beams and columns, though the method has always been regarded as a comparatively rough approximation. Using the same example as before, it is difficult to imagine that the creep movement after one month in a specimen under a sustained stress of 200 lb. per square inch could equal that in an identical specimen on which the stress has been slowly reduced over this period from 750 lb. to 200 lb. per square inch; yet the error in this assumption may not be so great as would appear at first sight. If the composition of the cement gel remained constant and moisture movements were not affected by its conversion to a more stable form, then, according to the mechanism of the inelastic movements previously described, the equilibrium vapour pressure and moisture content when all creep movements had taken place would depend only on the magnitude of the final stress. Thus, as shown by tests under constant stress, the ultimate creep and stress would be directly proportional and, since stresses at intermediate times would each tend to establish the corresponding moisture content, a close approximation to direct proportionality could be expected at all times.

This may be illustrated by the results obtained by Professor A. D. Ross in tests on struts of phenolic plastic. The creep properties of this material are similar to those of concrete, in that deformations under constant sustained loads are at all times proportional to the stress, but its composition is not subject to variation. In these tests on instability, creep movements occurred under progressively varying stress, but it will be seen from Fig. 1, on page 309, that the effects are in remarkably close agreement with those calculated by the effective modulus method.

The error introduced, then, when this method is used to calculate creep movements in concrete under varying stress, can be attributed largely to changes in the rate of conversion of the gel to the stable form. Now, in the above specimen, under decreasing stress, creep movements in the initial stages will be comparatively great, so that, when the stress has been reduced to, say, 600 lb. per square inch, the moisture expelled from the gel will be greater than that expelled by a constant stress of 600 lb. per square inch on an identical specimen. The former specimen will therefore contain less moisture in the gel, a lower proportion will reach the stable form, and the creep properties will be slightly increased. Similar increases will occur throughout the period of stress variation, and thus, under decreasing stress conditions, creep movements and effects will be under-estimated in calculations based on an effective modulus determined from tests under constant stress. It is worthy of note that both this method and that using the rate of creep expression $\frac{dC}{dt} = f\,\phi'\,(t)$ are only suitable for calculating creep movements under progressively varying stress and cannot be used when sudden changes in load take place.

The method of model analysis was developed by Professor A. D. Ross in order to include the influence of the stress history of the concrete in the analysis of creep effects, but it also provides a general method of calculation for all types of stress variation. The behaviour of concrete under load is represented with the aid of an idealised model constructed of two basic units, a perfectly elastic spring, and a viscous element in which the resistance is assumed to be proportional to the velocity of deformation; by a suitable combination of these elements a model can be obtained (as shown in the diagram, Fig. 2, on page 309) which exhibits the characteristic elastic creep and shrinkage properties of concrete.

If a load f is rapidly applied and subsequently sustained, there is an immediate elastic deformation of spring 1 followed by a progressive deformation with time (creep) as the piston moves in the cylinder. The rate at which this inelastic deformation takes place is progressively reduced as spring 2 takes an increasing proportion of the load, until eventually a static condition representing ultimate creep is attained. The representation of shrinkage is achieved by the assumption of an internal force p acting on the piston, which produces a non-elastic continuous deformation of similar form to that produced by f without the corresponding elastic movement; while, if the model is connected in parallel with a third elastic spring, the conditions obtaining in a symmetrically reinforced-concrete column are reproduced. From a consideration of the mechanics of this simple system under constant load, expressions for the creep and shrinkage movements can be obtained, and, by suitable choice of spring and piston constants, can be fitted closely to experimental results. Having thus determined the constants, deformations under any other stress conditions can be calculated readily.

As in the effective-modulus method, the ultimate deformation of the model will depend only on the magnitude of the final stress and, since no allowance

is made for changes in the rate of moisture conversion, the two methods will give the same result ultimately. At intermediate times, however, creep movements in the model under decreasing stress are rather greater than those calculated by the effective-modulus method, and, with the inclusion of stress history effects in the analysis, it seems highly probable that this method will give a closer approximation to the actual deformations in concrete than either of those described previously. Unfortunately, the somewhat lengthy and complicated nature of the resulting expressions and the difficulty of extending the method to the calculation of creep effects in reinforced-concrete beams make model analysis rather unsuitable for use in design.

The principle of superposition was first suggested by W. H. Lorman for the calculation of creep movements under varying stress. The equation $C = \frac{m\,t}{n + t}\,f$, where C is the creep, f the stress, t the time after loading, and m and n are constants, was used to express the magnitude of creep movements in a specimen under constant stress, and it was assumed that the creep resulting from any subsequent load applications would be independent of that due to the initial stress f. Thus, for a load applied in two increments Δf_1 and Δf_2, the increments becoming effective at t_1 and t_2, respectively, the creep movement at any subsequent time, t, is given by the expression

$$C = \frac{m_1 (t - t_1)}{n_1 + (t - t_1)}\,\Delta f_1 + \frac{m_2 (t - t_2)}{n_2 + (t - t_2)}\,\Delta f_2,$$

the two sets of constants m_1, n_1, and m_2, n_2 being necessary to take account of the variation in creep properties of the concrete with the time of application of the load. By an extension of this process, if a large number, N, of stress increments are applied at regular time intervals and if the rate of loading is known, the creep-time relationship is expressed in the form

$$C = \sum_{x=1}^{x=p} m_x \frac{t - t_x}{n_x - (t - t_x)} \frac{\Delta f_x}{\Delta t_x}\,\Delta t_x,$$

and from this equation creep movements corresponding to any particular rate of loading can be obtained by an ordinary summation process. Such a method, however, would be extremely tedious and would also necessitate a number of constant-load creep tests carried out at different ages in order to obtain the requisite values of the constants m and n.

This latter difficulty was overcome by D. McHenry, who adopted a sustained-load creep-time expression incorporating the additional factor "age of loading":—

$$c = \alpha\,(1 - e^{-rt}) + \beta e^{-pk}\,(1 - e^{-mt}),$$

in which c = creep due to unit load, K = age at time of loading, t = time after loading, and α, β, r, p, and m are constants determined from laboratory tests.

Using this in conjunction with the principle of superposition, as before, the creep movements corresponding to simple forms of stress variation can be obtained by direct integration, but for more complicated cases graphical methods are again required. The results calculated in this way have been shown to be in good agreement with the stresses and strains in a concrete specimen maintained at constant length during a temperature cycle, but, in spite of this success, no attempt has been made to apply the method to simple structural problems. In view of the unwieldy form of the expressions, it is difficult to see how this could be achieved readily. Thus, while superposition might be adopted conveniently for the calculation of creep effects in members subjected to large and sudden changes in stress, its applications in other types of problem are unsuited to routine design procedure.

From the methods of calculation described in the previous section it will be seen that, for convenience, any allowance made for creep in the design of reinforced-concrete members under sustained loads must be calculated either by the effective-modulus method or from the rate of creep expression $\frac{d\,C}{dt} = f\,\phi'(t)$; although model analysis and superposition may give more accurate results, their application is undesirably complicated. It has also been shown, from a consideration of the nature of the inelastic deformations, that, under conditions of decreasing stress, creep movements will be under-estimated by the effective-modulus method but over-estimated by the use of the expression $\frac{d\,C}{dt} = f\,\phi'(t)$. In order to verify this result experimentally and to establish the probable position of the actual creep movements within the range calculated by these two methods, several tests have been carried out, of which the following are typical examples.

Creep movements were measured in a plain concrete specimen on which the stress was reduced progressively in accordance with the equation

$$f = 500 - \frac{t}{0{\cdot}0027 + 0{\cdot}0036t},$$

where f is the stress in lb. per square inch and t is the time in days. Simultaneous shrinkage and creep movements under constant stress were measured in identical specimens of the same mix, and from these the deformations in the specimen under varying stress were calculated by the effective-modulus method (corresponding to the creep equation $C = f\,\phi(t)$) from the expression $\frac{d\,C}{dt} = f\,\phi'(t)$, and by superposition. The results are shown in Fig. 3, on page 309. It will be seen that values calculated by superposition are in extremely good agreement with the actual deformations, which, as might reasonably be expected, lie approximately mid-way between those obtained by the less accurate, but very much simpler, methods.

A convenient method of investigating creep movements in concrete under varying stress is provided by the effects of the inelastic deformations in reducing the stress required to maintain a plain concrete member under constant strain. If the initial deformation of a specimen under compressive load be maintained constant, the gradual increase in creep and shrinkage necessitates a corresponding reduction in elastic strain and therefore a relief of stress. Thus creep movements take place under a progressively decreasing stress and their magnitude is indicated by the value of the residual load.

Tests of this kind can be carried out readily either on plain-concrete specimens under axial loads or on simply-supported beams. The latter type of test, in which the initial central deflection is maintained constant by reducing the load, is particularly convenient, since, for beams with symmetrical sections, shrinkage movements are the same on both sides of the neutral axis and no warping can be attributed to this cause. Changes in load are therefore due entirely to the effects of creep, and it has been shown by Dr. W. H. Glanville that, under these conditions, the residual load at any time, W_r, calculated from the rate of creep expression $\frac{d\,C}{dt} = f\,\phi'(t)$, can be expressed by the formula

$$W_r = W_0\,e^{-\frac{\delta_c}{\delta_0}},$$

where W_0 is the initial load, δ_0 is the initial deflection, e is the base for Napierian logarithms, and δ_c is the increase in central deflection due to creep of an identical beam on which the same initial load has been maintained constant. The corresponding expression calculated by the effective-modulus method is

$$W_r = \frac{W_0}{1 + \frac{\delta_c}{\delta_0}}.$$

The results obtained in a test of this kind on a small cement beam, 12 in. in length, with an initial load of 16 lb. at the centre of the span, are shown in Fig. 4, together with values calculated from the above expressions. These show, as in the previous test, that the effects of creep, and therefore the movements themselves, are over-estimated by the rate of creep expression $\frac{d\,C}{dt} = f\,\phi'(t)$ and under-estimated by the effective-modulus method.

Similar confirmation is also provided by the results of a test on a cylindrical specimen under axial load (Fig. 5, on page 310). In this case the initial elastic contraction under a stress of 477 lb. per square inch was maintained constant by reducing the load, and theoretical values for the residual stress were calculated from constant-stress creep and shrinkage movements measured in identical specimens of the same mix. Here, again, the experimental results lie between those calculated from the expression $\frac{d\,C}{dt} = f\,\phi'(t)$ and by the effective-modulus method.

In addition to confirming the previous discussion, the results of these tests also lead to the conclusion that the error involved when creep movements under varying stress are calculated by the effective-modulus method is no greater than that resulting from the use of the expression $\frac{d\,C}{dt} = f\,\phi'(t)$. It will be seen from Figs. 3, 4 and 5 that, in each case, the errors are of the order 10 per cent. approximately, but they are in opposite directions. Since, then, neither method possesses any advantage in accuracy, the ease with which creep effects are included in an analysis simply by adopting an effective modulus for the concrete makes this method particularly suitable for use in design. It is important, however, that an appropriate value of the effective modulus or effective modular ratio should be selected. After about one year the effective modulus of an ordinary-grade concrete under sustained stress in the laboratory is about $0{\cdot}75 \times 10^6$ lb. per square inch, and the stress distribution in reinforced-concrete members will correspond, therefore, to an effective modular ratio of about 40; on loading, the modular ratio is about 7·5. Thus, in order to calculate the conditions obtaining in a reinforced-concrete member during a period of one year under sustained load, it will be necessary to use different values of the modular ratio, varying between 7·5 and 40, according to the length of time which has elapsed since the load inducing these conditions was first applied. Since it is only possible to design a member to be in one particular condition, it becomes necessary to select a single value of the modular ratio from this range for use in design.

In employing a value of 15 or 18, present-day procedure uses the modular ratio corresponding to the conditions in a concrete structure only five or six days after loading. This means that, throughout the remaining life of the structure, the stress distribution in the members is different from that envisaged in the original design, and the magnitude of the discrepancy increases with time; the steel becomes over-stressed and the concrete under-stressed. Such conditions can be avoided only by the adoption of a higher modular ratio, and to this end it would seem desirable to increase the values in use at the present time.

The choice of a suitable modular ratio, however, is a subject in itself and cannot be discussed in this present paper. The appropriate value in any particular case will depend largely on the type of loading, but, in the opinion of the author, a figure of 27 would be most generally applicable. Its use in design would lead not only to more accurate calculations of the stresses and deflections in reinforced-concrete structures at all ages after about one year, but also, by preventing the concrete stress from falling appreciably below its working value, to a more economic use of this material.

ANNUALS AND REFERENCE BOOKS.

South African Mining and Engineering Year Book, 1946-47.—The 34th edition of this annual reference book, which now incorporates the *Rhodesian Mining Year Book* and is published by the South African Mining Journal Syndicate, Limited, 201-207, Jubilee House, Simmonds-street, Johannesburg, Union of South Africa, and Argus South African Newspapers, Limited, 85, Fleet-street, London, E.C.4, is essentially a comprehensive guide to the South African gold-mining industry, with additional sub-sections on base minerals, coal, copper, diamonds, and industrial and commercial companies. The first half of the book records the proceedings of the previous annual general meeting of almost every important mining company in Southern Africa, and therefore contains the latest available information from official sources. The directories in the latter part of the book follow a strictly alphabetical arrangement. The mining-directory section gives a detailed account of the history, capital, directorate, property, and essential details required to make a fair assessment of the position and prospects of each undertaking. Other features are a directory of Government departments and public bodies; a list of engineering firms in the Union of South Africa and in Northern and Southern Rhodesia; overseas manufacturers represented in South Africa; and a buyers' guide to mining and mining engineering specialities. The price of the book is 30*s.*

Newnes Engineer's Reference Book.—The original text of this book, which first appeared a year ago, has now been completely revised and amplified in numerous directions, with the intention of producing an authoritative and comprehensive work of reference embracing all branches of mechanical engineering. On account of the striking advances achieved during the war in such matters as workshop practice, machine-tool design and production methods, emphasis is placed rather on engineering processes than on mechanism. The same underlying motive has led the editor, Mr. F. J. Camm, to give special attention to standard specifications, aircraft construction, statistical control of manufactured products, and many new processes in metallurgy, surface treatment and fabrication. A score or so of experts have contributed separate articles on subjects—like plastics, powder metallurgy and factory lighting—which lie on the fringes of mechanical engineering. Engineers who feel that the value of the book is enhanced by concise instructive references to information that has not yet found its way into ordinary text-books may be inclined to criticise the editor for affording so much space to matter, such as tables of logarithms and section moduli, which is readily available elsewhere, while omitting all mention of numerous modern operations and devices that are well-established in mechanical engineering practice. On the whole, however, this is an admirable book of its kind and clearly no effort has been spared to make it accurate, reliable, and easily understood. It is published by Messrs. George Newnes, Limited, Tower House, Southampton-street, London, W.C.2, at the price of 42*s.* net.

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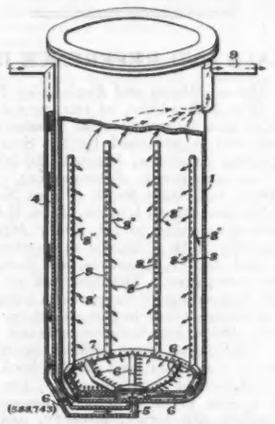
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

FURNACE APPARATUS.

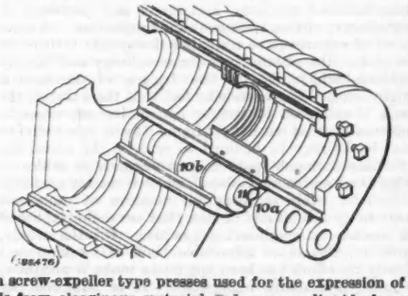
588,743. Furnace. Wild-Barfield Electric Furnaces, Limited, of Watford, Herts, and F. W. Haywood and D. S. Laidler, both of Watford, Herts. (2 *Figs.*) February 5, 1945.—In heat-treatment furnaces it has been increasingly common practice to use fans for circulating the atmosphere in the chamber. The present invention consists in the use of numbers of jets of the atmosphere, directed into the furnace chamber. The retort 1 is suitably heated by electrical elements disposed in relation to the surrounding wall of a heating furnace containing the retort. The incoming carburising gas is carried down by gas-inlet pipe 4 through the hot zone outside the chamber 1 to an inlet 5 at the centre of the bottom of the chamber. A manifold, including a number of radial



branches 6 leading to a ring 7, is disposed at the bottom of the retort, in some cases beneath a grid, according to the method of support and proximity of the work. Further pipes 8 lead upward from the ring 7 and surround the work space. Apertures in the radial branches 6 are directed more or less horizontally and tangentially in the same sense to give a rotary and outward tendency to the flow, and apertures may also be provided in the ring 7. The main flow against the surfaces of the work is provided by apertures in vertical pipes 8, directed inwardly and radially as indicated by arrows 8', though some additional turbulence jets 8'' may be directed from the verticals. An outlet 9 leads the gas from the top of the chamber. (*Accepted June* 2, 1947.)

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

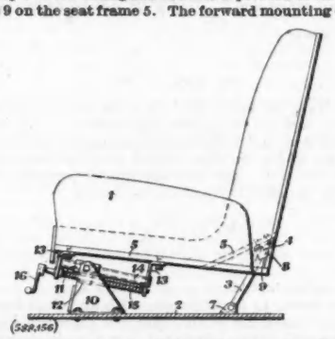
588,476. Mounting of Press Cage in Screw-Expeller Press. Rose, Downs and Thompson, Limited, of Kingston-upon-Hull, and F. J. Hindson, of Kingston-upon-Hull. (1 *Fig.*) February 21, 1945.—This invention concerns a method of mounting two or more portions of a press cage



on screw-expeller type presses used for the expression of oils from oleaginous material and aqueous liquids from moisture containing materials. The object of the invention is to provide a method for mounting two or more portions of the press cage so that they can swing. A hinge 11 of large diameter extends through the whole length of the cage. On each half of the cage casting there are integral bosses 10*a*, 10*b*, respectively, of sufficient strength to resist that pressure within the cage tending to separate the two halves of the cage. The hinged bosses 10*a*, 10*b*, on both halves of the cage thus interlock side by side. The large-diameter hinge member 11 passes through the bosses 10*a*, 10*b* on both halves of the cage and extends beyond the ends of the cage where the ends enter suitable support brackets on the base of the press, so that the weight of the press is supported on its base. As the hinged bosses interlock closely side by side along the whole length of the cage, the end thrust upon the cage, due to the movement of the press on the cage, is also transferred to the base of the machine. By utilising this form of hinging, the heavy clamping gates previously employed for use with present forms of screw-press cages are eliminated from the hinge side of the cage, and the end thrust upon the cage is transferred to the base of the machine instead of being carried upon the pressed-material discharge part of the press, where it is less convenient to accommodate the cage and thrust. *Sealed.*

MOTOR VEHICLES.

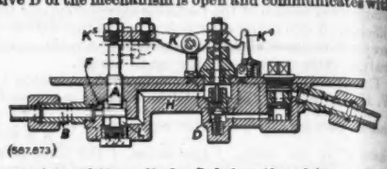
588,156. Adjustable Seat. Jowett Cars, Limited, of Bradford, Yorkshire, and R. J. Korner, of Bradford. (3 *Figs.*) December 18, 1944.—The invention is a seat for use in motor vehicles or elsewhere, which is adjustable in both horizontal and vertical planes. It has a three-point mounting on the floor, designed to prevent twisting of the seat, which causes jamming, when it is moved backward or forward. At the rear of the seat 1 are a pair of spaced links 3 pivoted at 4 to the seat frame 5 and to the floor 2 of the vehicle. Each link 3 is in the form of a triangular bracket having its base or widest part pivoted to a bracket 7 so that its axis of rotation lies across the vehicle, thus allowing the link 3 to pivot forward and backward in line with the direction of adjustment of the seat, but not allowing any side play. The top 8 of the triangular bracket is pivoted to an angle piece 9 on the seat frame 5. The forward mounting of the



seat is centrally placed relative to the rear mountings and consists of a bracket 10, rigidly secured to the floor 2, having at its upper end a pivoted bush 11 which carries a screw nut 12. Attached to the seat frame 5 are a pair of brackets 13 carrying a guide rod 14 at an angle to the level of the underside of the seat frame 5. The guide rod 14 passes through the bush 11 and a screwed rod 15 is carried beneath the guide rod 14 to engage and pass through the screwed nut 12. The screwed rod 15 is turned by means of a handle 16 situated below the front of the seat frame. If necessary, additional support rollers can be provided at the forward corners of the seat. In operation, the actuation of the front adjusting mechanism causes forward and backward movement of the seat and raising and lowering of the front end of the seat, while, at the same time, the seat brackets or links 3 raise and lower the rear part of the seat 1, which pivots about the front mountings in a vertical plane. (*Accepted May* 15, (1947.)

SHIPS AND NAUTICAL APPLIANCES.

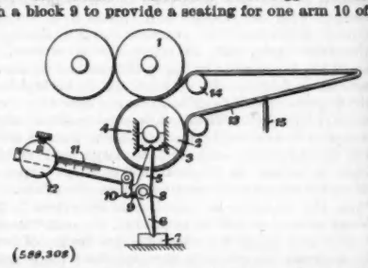
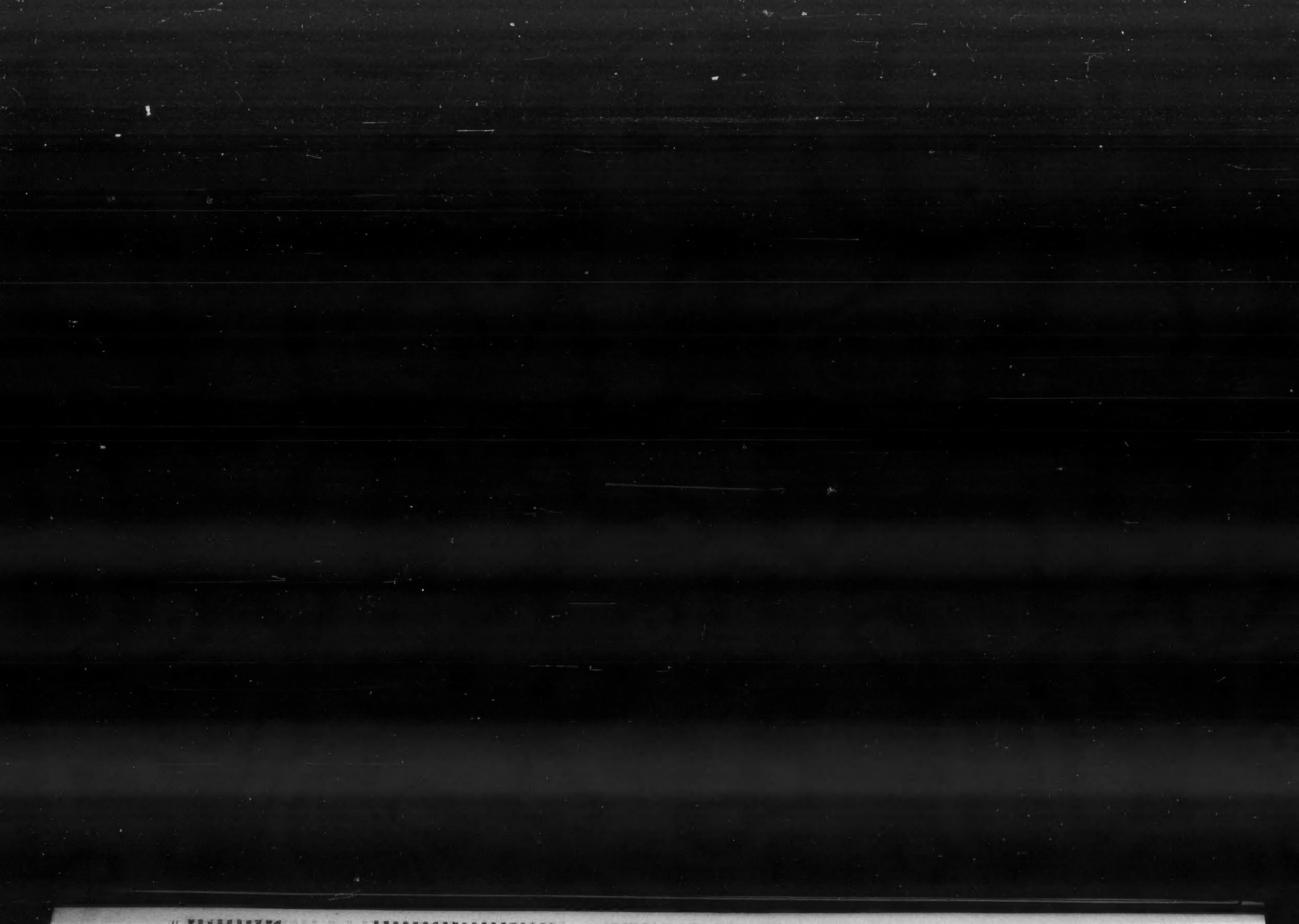
587,873. Automobile Torpedo. The Whitehead Torpedo Company, Limited, of Weymouth, and L. Jones, of Weymouth. (1 *Fig.*) July 26, 1938.—The invention is a head-ballast blowing mechanism for automobile torpedoes for the purpose of bringing the torpedo to the surface at the end of its run. It has been found that the air valve used in such mechanisms suffers from the disadvantage that the valve operating lever occasionally fails to hook itself under the retaining catch provided for it owing to insufficient opening of the valve, this insufficient opening occurring when the torpedo has only a small negative buoyancy at the end of its travel, or fails to stop quickly and continues to paddle along. Sufficient water or ballast will be blown from the torpedo upon the opening of the valve to enable the torpedo to become buoyant and float on the surface, but the pressure on the outside of the valve will then be decreased, and if the valve is not retained in the open position it will close and prevent any more air escaping into the head. The engine and heater of the torpedo will then gradually fill with water, and the result may be that the torpedo, having only a few pounds of positive buoyancy, will float away and, being practically invisible, may be lost. The object of the present invention is to overcome the above disadvantage. A cylindrical chamber L is formed in the body H of the torpedo and communicates with a passage leading from the air valve D and an outlet passage B leading into the torpedo head. A plunger A is fitted with a piston which reciprocates in the chamber L. In the normal position of the piston the passage from the operating valve D of the mechanism is open and communicates with



the portion of the cylinder L below the piston and the outlet to the passage B leading into the torpedo head is closed by the piston. A small hole F is drilled from the top of the cylinder L to the passage B. The top of the plunger A co-operates with an extension K^5 formed on the valve-operating lever K on the opposite side of the pivot to that which co-operates with the retaining catch K^4. It will be seen that, immediately the valve D is opened, and prior to the lever K engaging its retaining catch K^4, compressed air will flow into the part of the chamber L beneath the piston and be unable to escape quickly enough to avoid a pressure being built up. This pressure will force the piston and plunger A upwards to the limit of their travel and the plunger, impinging on the extension K^5 of the valve lever K, will force this end of the lever in the upward direction about its pivot. The hook end will thus be forced downwards and into engagement with the retaining catch K^4. The valve D is thus retained in the open position until the head is completely blown. (*Accepted May* 8, 1947.)

MISCELLANEOUS.

588,308. Biscuit-Moulding Machine. Baker Perkins, Limited, of Peterborough, Northampton, and J. C. Paterson, of Halifax, Yorkshire. (4 *Figs.*) January 19, 1945.—This invention is an improved rotary biscuit-moulding machine wherein the biscuit dough shapes are extracted from the cavities of the die roll by a rubber-covered pressure extraction roll operating through an endless band, to which the extracted shapes adhere and are conveyed away for delivery. Different types of biscuit dough require different degrees of pressure to accomplish the proper extraction of the dough from the die cavities. In machines as previously constructed, the pressure required is a matter of trial and error and suffers from the attendant disadvantages. The invention facilitates the pressure setting of the extraction rolls so that any selected pressure may be employed. Beneath the die roll 1 an extraction roll 2 is mounted in bearings 3 adapted to slide in vertical guideways 4. Each bearing is supported upon a toggle device consisting of a pair of toggle links 5, 6 pivoted together at 8. The outer end of the toggle lever 6 rests in a slot in the abutment plate 7 carried by the base of the machine. The link 5 of the toggle is formed with a block 9 to provide a seating for one arm 10 of a



bell-crank lever pivoted to a fixture on the machine frame, while the other arm 11 of the bell-crank lever is extended to carry a sliding weight 12. The arm 11 is provided with notches and is graduated to indicate the pressure effect of the weight at different positions on the slideway. The free end of the toggle lever 5 engages with a slot in the lower surface of the bearing 3. The weight 12, operating through the bell-crank lever 10, 11 and seating block 9, exerts a pressure upon the toggle links 5, 6 to displace the pivot 8 towards the straight line joining the attachment to the roll bearing and the abutment connection, and hence displaces the adjacent end of the extraction roll 2 towards the die roll 1, thus applying an extraction pressure corresponding with the position of the weight on the bell-crank lever. The device described is the same for both sides of the machine, so that each end of the extraction roll may be adjusted independently. The extraction roll 2 has an endless band 13 lapped around it which passes between it and the die roll 1. The band is supported on a guide roll 14 arranged to enable the band to lap the die roll 1 to any desired extent before passing away to a knife edge or other delivery point 15. (*Accepted*: *May* 20, 1947.)